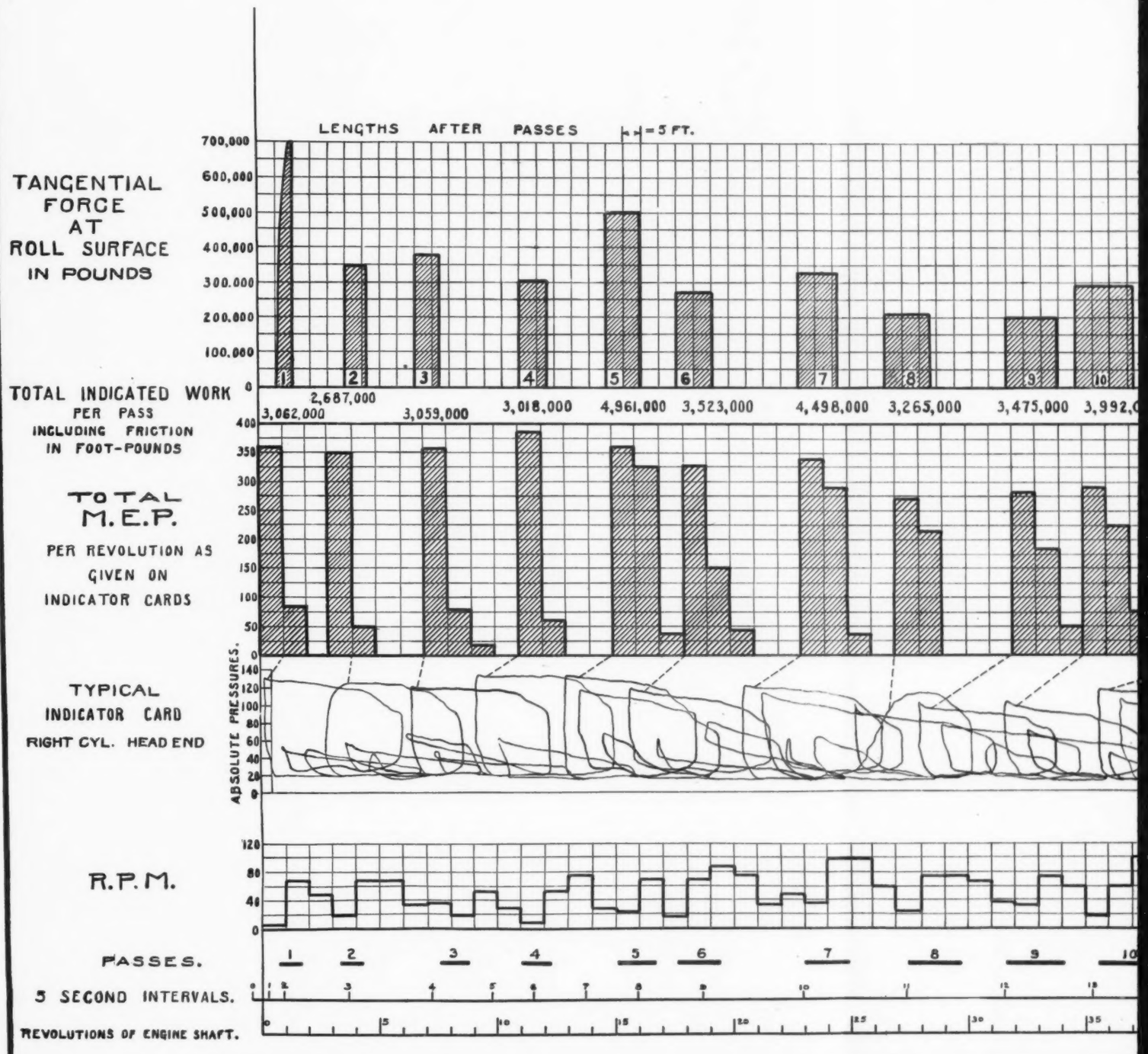
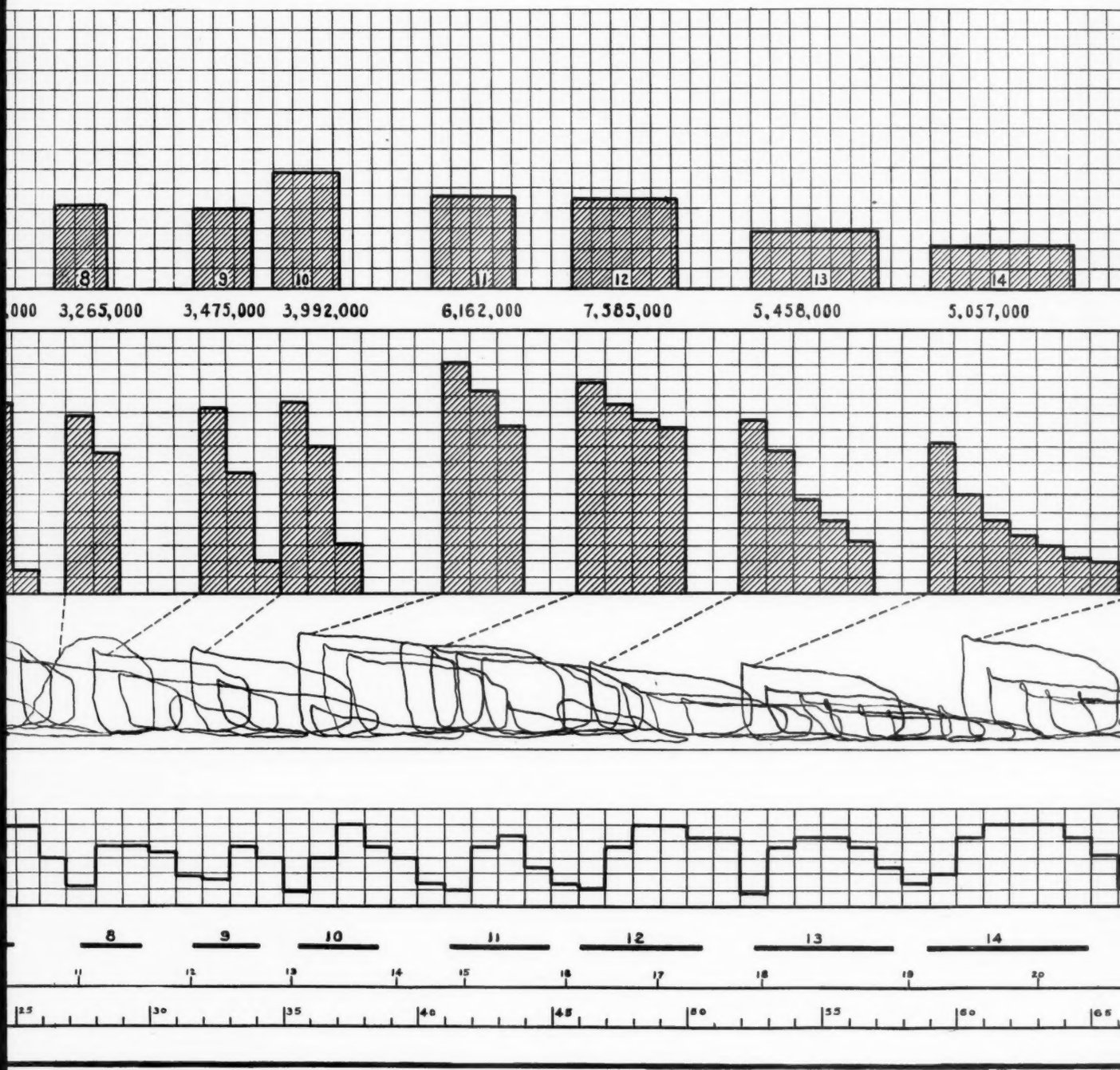
GRA


LENGTHS AFTER PASSES
= 5 FT.
TANGENTIAL FORCE AT ROLL SURFACE IN POUNDS
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1
2
3
4
5
6
7
8
9
10
TOTAL INDICATED WORK PER PASS INCLUDING FRICTION IN FOOT-POUNDS
3,062,000
2,687,000
3,059,000
3,018,000
4,961,000
3,523,000
4,498,000
3,265,000
3,475,000
3,992,0
TOTAL M.E.P. PER REVOLUTION AS GIVEN ON INDICATOR CARDS
400
350
300
250
200
150
100
50
0
TYPICAL INDICATOR CARD RIGHT CYL. HEAD END
ABSOLUTE PRESSURES.
140
120
100
80
60
40
20
0
R.P.M.
120
80
40
0
PASSES.
5 SECOND INTERVALS.
REVOLUTIONS OF ENGINE SHAFT.

GRAPHICAL EXHIBIT O

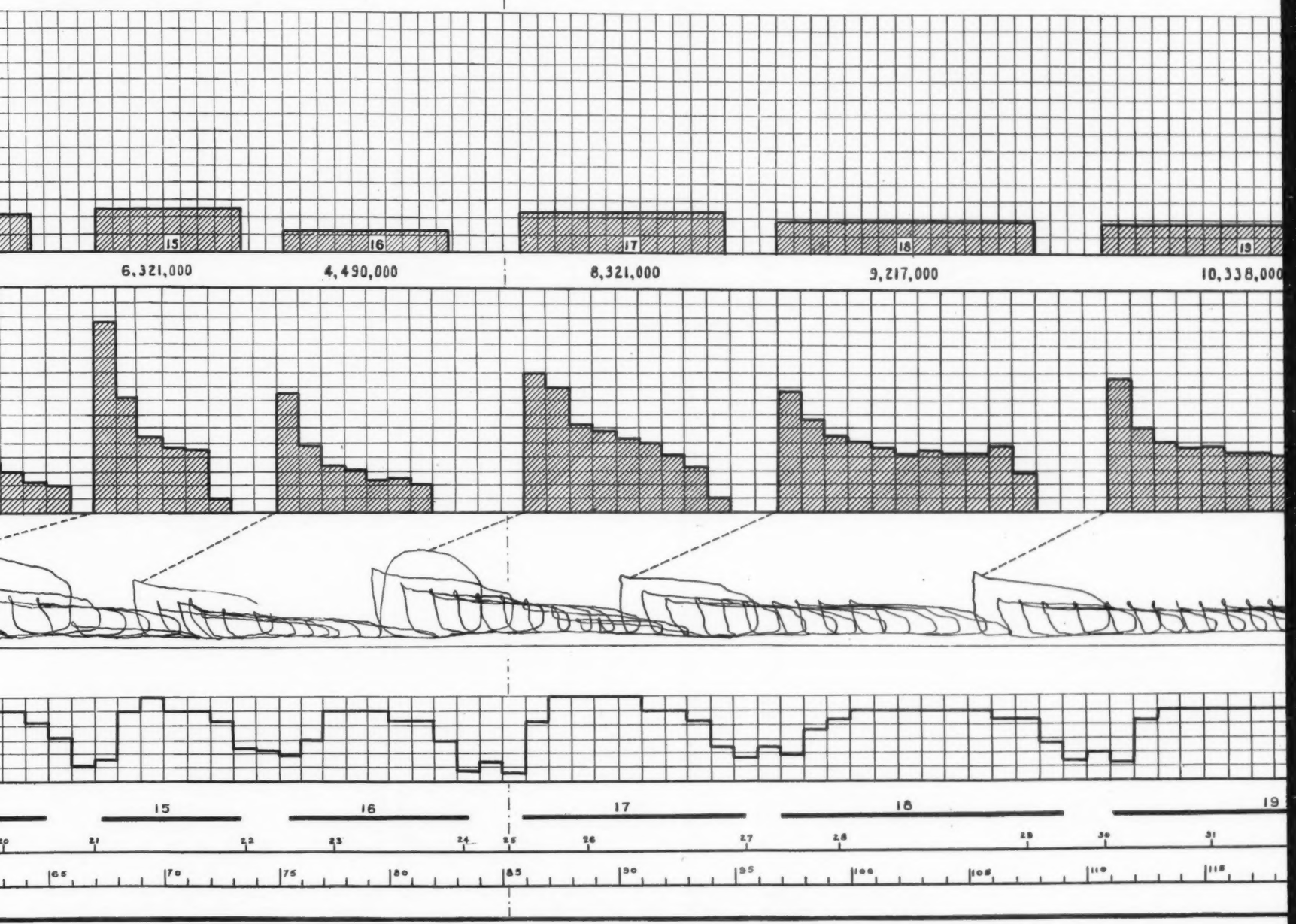
RESULTS OF TEST OF 35-IN.



OF CONDITIONS DURING ONE MILL

HN. BLOOMING MILL ENGINE AT INTERNATIONAL HARVESTER COM

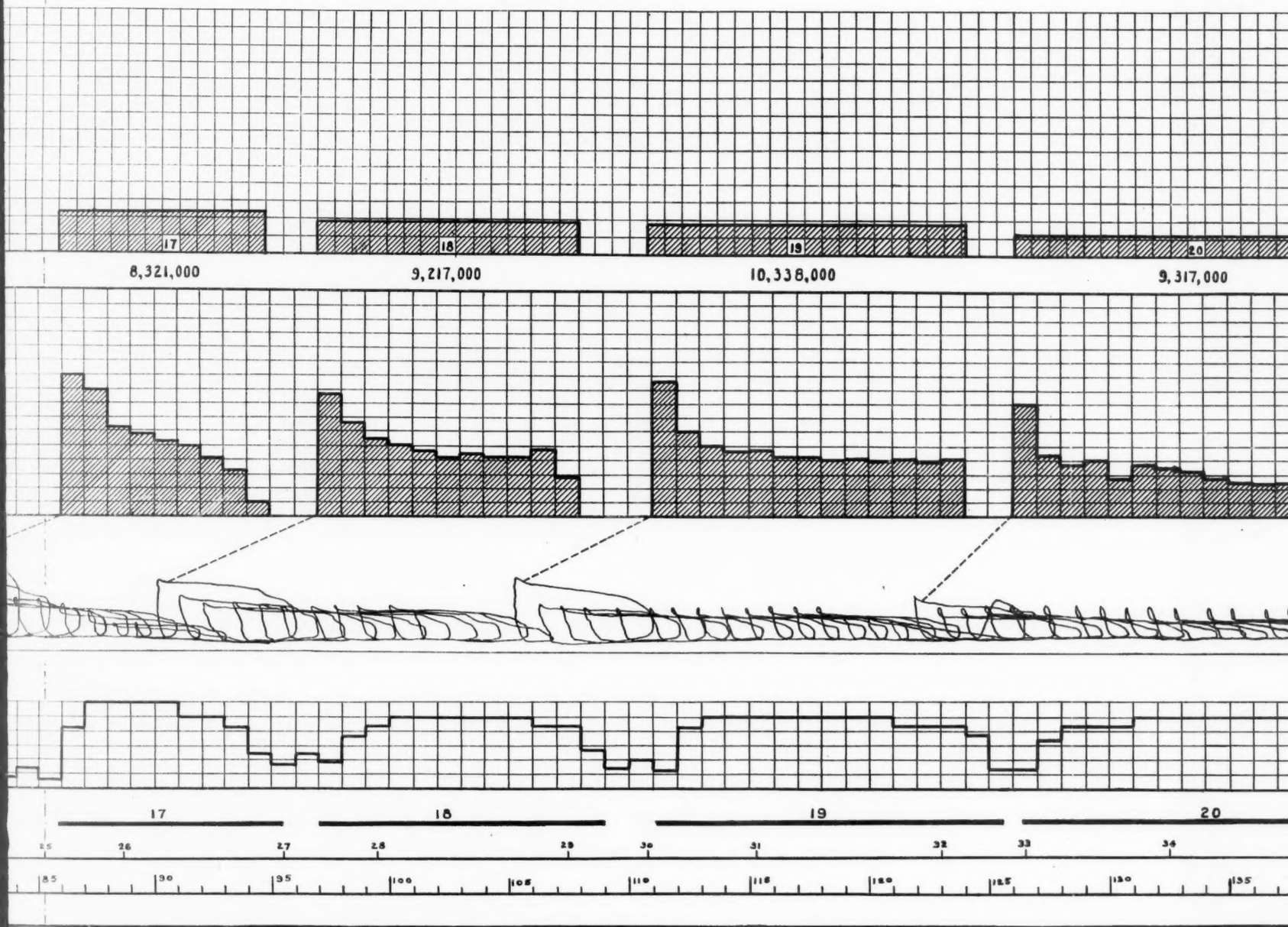
FIG. No. 1

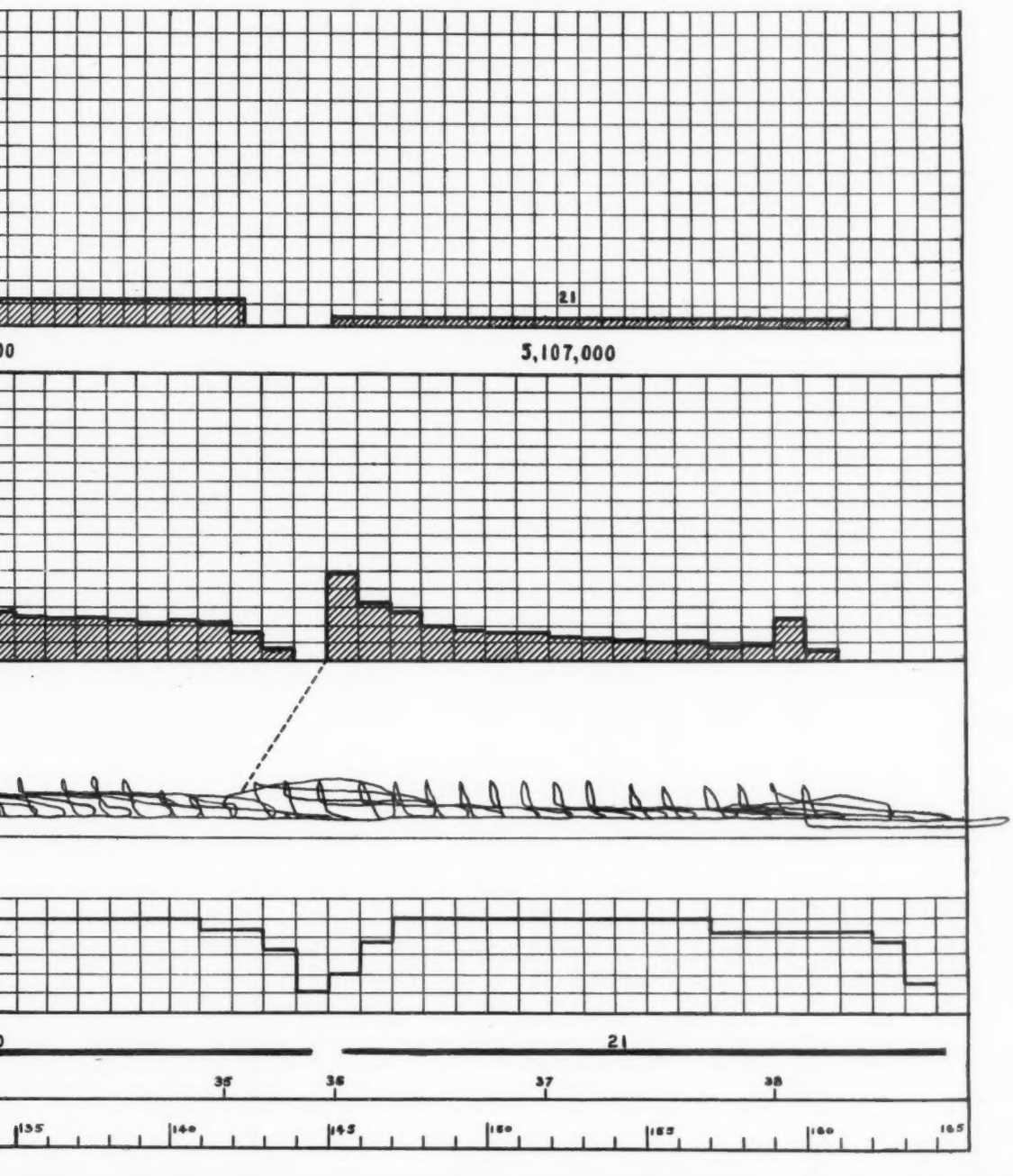


NS DURING ONE MILL CYCLE.

NE AT INTERNATIONAL HARVESTER COMPANY.

O. 1




21
5,107,000
21
35
36
37
38
135
140
145
150
155
160
165

conducted at these high velocities or with pipes of large diameters.

Though applicable directly to pipes 100 feet long with mean pressure of 100 pounds per square inch absolute, they may be used for any length or pressure. For example, for any length other than 100 feet multiply the drop given in the curves by the required length in feet and divide by 100. For any pressure other than 100 pounds absolute, multiply the drop given in the curves by 0.2271 (= density of steam at 100 pounds) and divide by the density of steam at the required pressure.

Table 5 is the table ordinarily used in connection with the flow of steam, and is calculated from equation (11). This table is simple and requires no special directions. Table 6 is based upon equations (4) or (12). The results differ but slightly from those in Table 5, though the former table is more comprehensive. The left-hand half of Table 6 gives the discharge in pounds per minute for pipes of various diameters corresponding to drop of pressure as given on the right-hand side in the same horizontal line; i.e., a 6-inch pipe 1000 feet long discharges 371 pounds of water per minute for a drop of 16.4 pounds at 100 pounds pressure, etc.

Equation of Pipes

It is frequently desirable to know what number of one-sized pipes will be equal in capacity to another pipe. The two rules most commonly used in this connection are based on Weisbach's and Unwin's formulas for friction.

According to the formulas in group 2, Table 2, the weights discharged vary with the square root of the fifth power of the diameter; that is, the number of one-sized pipes equal in capacity to any given pipe may be determined from the equation:

$$N_1 = d^{\frac{5}{2}} \div d_1^{\frac{5}{2}}, \qquad (18)$$

in which N_1 = number of pipes of diameters d_1, equal in capacity to a pipe of diameter d; d_1 and d in inches.

According to the formulas in group 1, Table 2, the weights discharged vary as

$$\left\{ d^5 \div \left(1 + \frac{3.6}{d}\right) \right\}^{\frac{1}{2}},$$

and the equation becomes:

$$N_1 = \left(\frac{d^5}{1 + \frac{3.6}{d}} \div \frac{d_1^5}{1 + \frac{3.6}{d_1}} \right)^{\frac{1}{2}} \qquad (19)$$

$$= \left\{ \frac{d^6 (d_1 + 3.6)}{d_1^6 (d + 3.6)} \right\}^{\frac{1}{2}} = \frac{d^3 \sqrt{d_1 + 3.6}}{d_1^3 \sqrt{d + 3.6}} \qquad (20)$$

From (18) and (20) we see that the values of N_1 are practically the same when the ratio of d to d_1 is small, and that they differ widely for large ratios. For example, according to (18), 5.7 eight-inch pipes are equivalent in capacity to one 16-inch pipe, whereas (20) gives 6.15. The difference is negligible. Again according to (18), 181 two-inch pipes are equivalent in capacity to one 16-inch pipe, whereas (20) gives 274. The difference is considerable. Equation (20) is most commonly accepted in this capacity.

Table 5. Flow of Steam Through Pipes (Babcock)

Initial Pressure by Gage. Pounds per Square Inch.	Diameter of Pipe, in inches. Length of each = 240 diameters.													
	¾	1	1½	2	2½	3	4	5	6	8	10	12	15	18
	Weight of Steam per Minute, in pounds, with one pound loss of pressure.													
1	1.16	2.07	5.7	10.27	15.45	25.38	46.85	77.3	115.9	211.4	341.1	502.4	804	1177
10	1.44	2.57	7.1	12.72	19.15	31.45	58.05	95.8	143.6	262.0	422.7	622.5	996	1458
20	1.70	3.02	8.3	14.94	22.49	36.94	68.20	112.6	168.7	307.8	496.5	731.3	1170	1713
30	1.91	3.40	9.4	16.84	25.35	41.63	76.84	126.9	190.1	346.8	559.5	824.1	1318	1930
40	2.10	3.74	10.3	18.51	27.87	45.77	84.49	139.5	209.0	381.3	615.3	906.0	1450	2122
50	2.27	4.04	11 2	20.01	30.13	49.48	91.34	150.8	226.0	412.2	665.0	979.5	1567	2294
60	2.43	4.32	11.9	21.38	32.19	52.87	97.60	161.1	241.5	440.5	710.6	1046.7	1675	2451
70	2.57	4.58	12.6	22.65	34.10	56.00	103.37	170.7	255.8	466.5	752.7	1108.5	1774	2596
80	2.71	4.82	13.3	23.82	35.87	58.91	108.74	179.5	269.0	490.7	791.7	1166.1	1866	2731
90	2.83	5.04	13.9	24.92	37.52	61.62	113.74	187.8	281.4	513.3	828.1	1219.8	1951	2856
100	2.95	5.25	14.5	25.96	39.07	64.18	118.47	195.6	293.1	534.6	862.6	1270.1	2032	2975
120	3.16	5.63	15.5	27.85	41.93	68.87	127.12	209.9	314.5	573.7	925.6	1363.3	2181	3193
150	3.45	6.14	17.0	30.37	45.72	75.09	138.61	228.8	343.0	625.5	1009.2	1486.5	2378	3481

For any other length divide 240 by the given length expressed in diameters and multiply the tabular quantity by the square root of this quotient, which will give the flow for one pound loss of pressure. Conversely, dividing the given length by 240 will give the loss of pressure for the flow given in the table.

Table 6. Flow of Steam Through Pipes (Sickles)

Length of pipe one thousand feet.

Discharge in Pounds per Minute Corresponding to Drop in Pressure on Right for Pipe Diameters in Inches in Top Line.											Drop in Pressure in Pounds per Square Inch Corresponding to Discharge on Left; Densities and Corresponding Absolute Pressures per Square Inch in First Two Lines.								
Diameter.	12"	10"	8"	6"	4"	3"	2½"	2"	1½"	1"	Density. Pressure.	0.208 90	0.230 100	0.284 125	0.328 150	0.401 180	0.443 200	0.506 230	0.548 250
Discharge	2328	1443	799	371	123.	55.9	28.8	18.1	6.81	2.52	Drop.	18.10	16.4	13.3	11.1	9.39	8.50	7.44	6.87
"	2165	1341	742	344	114.6	51.9	27.6	16.8	6.52	2.34	"	15.60	14 1	11.4	9.60	8.09	7.33	6.41	5.92
"	1996	1237	685	318	106.	47.9	26.4	15.5	6.24	2.16	"	13.3	12.0	9.74	8.18	6.90	6.24	5.47	5.05
"	1830	1134	628	292	97.0	43.9	25.2	14.2	5.95	1.98	"	11.1	10.0	8.13	6.83	5.76	5.21	4.56	4.21
"	1663	1031	571	265	88.2	39.9	24.0	12.9	5.67	1.80	"	9.25	8.36	6.78	5.69	4.80	4.34	3.80	3.51
"	1580	979	542	252	83.8	37.9	22.8	12.3	5.29	1.71	"	8.33	7.53	6.10	5.13	4.32	3.91	3.42	3.16
"	1497	928	514	239	79.4	35.9	21.6	11.6	5.00	1.62	"	7.48	6.76	5.48	4.60	3.88	3.51	3.07	2.84
"	1414	876	485	226	75.	33.9	20.4	10.9	4.72	1.53	"	6.67	6.03	4.88	4.10	3.46	3.13	2.74	2.53
"	1331	825	457	212	70.6	31.9	19.2	10.3	4.43	1.44	"	5.91	5.35	4.33	3.64	3.07	2.78	2.43	2.24
"	1248	873	428	199	66.2	23.9	18.0	9.68	4.15	1.35	"	5.19	4.69	3.80	3.19	2.69	2.44	2.13	1.97
"	1164	722	400	186	61.7	27.9	16.8	9.03	3.86	1.26	"	4.52	4.09	3.31	2.78	2.34	2.12	1.86	1.72
"	1081	670	371	172	57.3	25.9	15.6	8.38	3.68	1.17	"	3.90	3.53	2.86	2.40	2.02	1.83	1.60	1.48
"	998	619	343	159	52.9	23.9	14.4	7.74	3.40	1.08	"	3.32	3.00	2.43	2.04	1.72	1.56	1.36	1.26
"	915	567	314	146	48.5	21.9	13.2	7.10	3.11	0.99	"	2.79	2.52	2.04	1.72	1.45	1.31	1.15	1.06
"	832	516	286	132	44.1	20.0	12.0	6 45	2.83	0.90	"	2.31	2.09	1.69	1.42	1.20	1.08	0.949	0.877
"	748	464	257	119	39.7	18.0	10.8	5.81	2.55	0.81	"	1.87	1.69	1.37	1.15	0.97	0.878	0.769	0.710
"	665	412	228	106	35.3	16.0	9.6	5.16	2.26	0 72	"	1.47	1.33	1.08	0.905	0.762	0.690	0.604	0.558
"	582	361	200	92.8	30.9	14.0	8.4	4.52	1.98	0.63	"	1.13	1.02	0.828	0.695	0.586	0.531	0.456	0.429

To get the pressure drop for lengths other than 1000 feet, multiply by lengths in feet ÷ 1000.

Tests show that the non-condensing hoisting engines used in mining operations consume from 80 to 100 pounds of steam per effective horse-power in mineral hoisted.

Fly-wheel Explosions

On the night of March 24 the 20-foot belt-wheel of a pair of 25x48-inch Wetherill-Corliss engines at the Susquehanna avenue station of the Philadelphia Electric Company went to pieces, occasioning considerable property damage, but, fortunately, no personal injury. The accident is said to have been due to the parting of a 48-inch three-ply belt, presumably disabling the governor. A fragment of the wheel opened a 10-inch steam main which was under 170 pounds pressure. A large piece went through the second floor and roof, hitting the brick stack at a point 36 feet above the building, and falling back upon one of the batteries of boilers. Several pieces were thrown across the street, one piece passing through four walls of the residence block opposite and landing in the back yard, a distance of 150 feet from the point of starting. Several other pieces bombarded the block, and that some of the occupants were not injured is to be wondered at. Views showing part of the resultant damage are presented herewith. The engine was not provided with an automatic safety stop.

Shortly after noon, on March 19, the belt-wheel of a 375-horse-power Fulton-Corliss engine at the electric station of the Muscogee (I. T.) Gas and Electric Company burst, partially wrecking the engine, ruining the switchboard, and badly damaging a generator and the building. The wheel was 22 feet in diameter, 31 inches face, made in halves, with bolted joints half way between the arms, of which there were six. The failure, as the accompanying engraving shows, occurred in the rim, the arms remaining intact. The governor belt was found to have been broken in two, and the inference is that this caused the accident. No automatic safety stop was used, and no information is available as to the manner in which the valves were set, or whether the governor was blocked up. The loss, $3159, was settled by the Fidelity and Casualty Company.

On March 30 an 8½-foot rope-wheel, the rim of which was 18 inches in width grooved for 10 ropes, failed at the works of the Chicago Coated Board Company. The rope was severed in several places, the tension sheave and carriage were broken, as was the governor of the Buckeye engine to which it was attached. It is supposed that the initial failure was in the rope. Flying pieces broke heavy timbers, damaged machinery, broke a steam main and scalded an employee to death. Here, also, there was no safety stop in use, but the wheel was insured by the Fidelity company. A view of the wreck is shown in one of the accompanying engravings.

On March 25 a 15-foot fly-wheel exploded at the Bessemer (Ala.) Rolling Mill with great violence, scattering its pieces widely, but injuring nobody. Again, no automatic safety.

On April 5 one of the Harrisburg engines in the Hotel Knickerbocker, New York City, broke its 10-foot wheel, causing considerable confusion, knocking holes in the main floor and injuring a man in the barber shop. Still again, no safety stop.

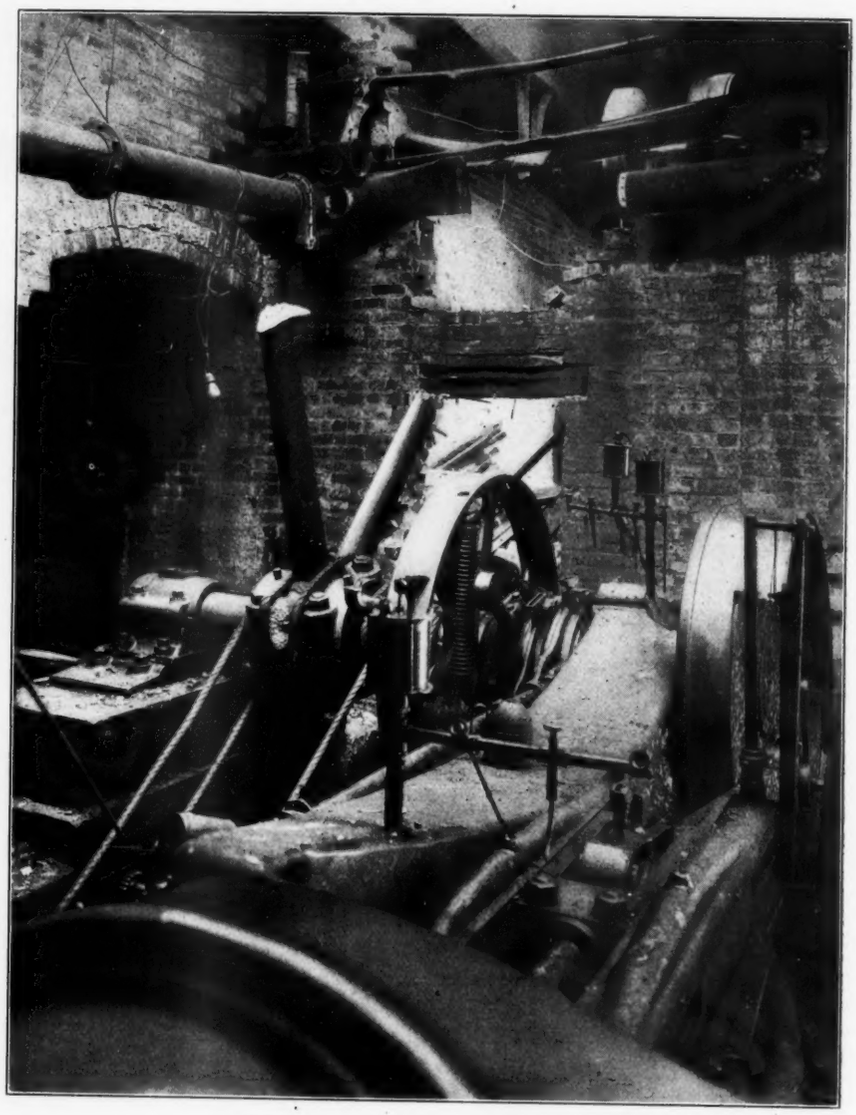
One afternoon during the latter part of April a 2-ton iron fly-wheel in the paper machine establishment of Moore & White, of Philadelphia, burst, wrecking the engine room and injuring a workman.

On April 17 the 13-foot fly-wheel of a Corliss engine at the Brookhaven (Miss.) electric lighting and water works power station "exploded." The wheel was stripped off and sections of it were thrown several hundred yards, tearing holes in a brick wall and the iron roof. Lightning is supposed to have been the cause by bringing about a short circuit which caused a sudden, extreme strain on the wheel.

On April 19 a fly-wheel broke in the plant of the Youngstown (O.) Iron Sheet and Tube Company, causing much damage to machinery, but no injury to person.

On May 1 an 8-foot fly-wheel on an engine in the refrigerating plant of the Hotel Selwyn, at Charlotte, N. C., ran away and burst into several sections, some of which weighed from 100 to 400 pounds. The largest of these went through eight inches of concrete into the hotel office overhead, another was embedded in the brick wall, and still another flew into the dynamo room adjoining. Machinery, water pipes, ammonia lines, the hotel china and the building were damaged about $4000 worth. It was stated that the accident was caused by a helper allowing the cord of an extension lamp to become caught in the governor belt, throwing the belt off.

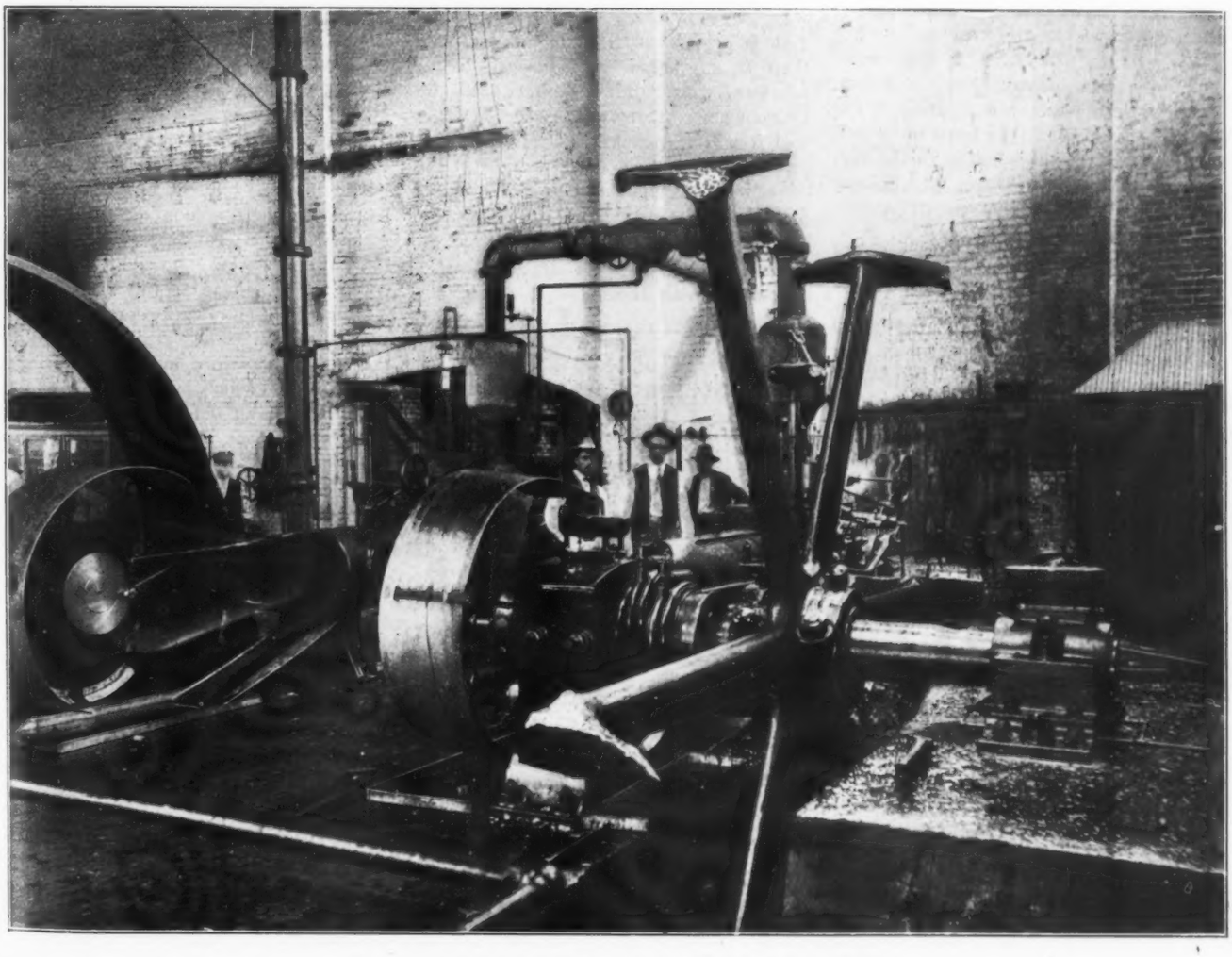
On May 5 a fly-wheel in the plant of the Ryegate Paper Company, at East Ryegate, Vt., burst and caused damage to the mill and machinery amounting to $10,000. None of these had a safety stop.



FLY-WHEEL WRECK, CHICAGO COATED BOARD COMPANY

WHERE A PIECE OF THE PHILADELPHIA WHEEL WENT OUT

WHERE A PIECE OF THE PHILADELPHIA WHEEL WENT IN



FLY-WHEEL WRECK, MUSCOGEE GAS AND ELECTRIC COMPANY

Burning Ashes Is Still a Burning Theme

Authorities Declare There Is Nothing in Salt and Oxalic Acid to Assist Combustion, but the Stock Is Still for Sale

What Professor Stillman Says

There seems to be a scientific fog in which certain people now and again come out with a proposition that 2 and 2 make 5. In nearly every instance they show that they are unacquainted with the principles of the conservation of energy. For instance, the burning of ashes shown by the New York papers as the work of a cobbler is indicative of a mind feeling for results without proper ground work.

Combustion is the result of the oxidation of carbon and hydrogen, neither of which appears in ashes. It has never been shown by any experiments at any college or university that ashes could produce heat. In fact, the contrary has been shown. Taking the formula of this cobbler from Altoona, we find that his mixture consists of ashes, sodium chloride, oxalic acid, water, and anthracite coal to the amount of one-third of the weight of the ashes. Now what is the result? In the first place, according to the formula, the water is the largest constituent, except the coal added. We know very well that water is not decomposed in the furnace to oxygen and hydrogen, as seems to be claimed. We also know that sodium chloride produces no heat, but absorbs it. We also know by direct experiment that oxalic acid makes no heat, but absorbs heat; consequently, the experiments that seem to show the combustion of ashes really indicate merely the amount of heat generated by the coal added according to the formula. Of course, the amount of coal added was enough to generate combustion, while the addition of sodium chloride gave a heavy yellow flame, indicative of heat. However, there is no record that thermal tests were made with a calorimeter to show the B.t.u. per pound of compound.

I will draw attention to United States Patent Re-347078—Compound for Perfecting the Combustion of Coal and Other Fuels; granted to George White, New York, Dec. 2, 1885. In this patent the use of sodium chloride, sodium sulphate, lime, cement, plaster, charcoal or other similar absorbent is proposed as for "the purpose herein set forth." *Look at that!* There is not one single constituent in that patent except the charcoal that will aid combustion, and the charcoal is a very small item. Why was that patent granted, when any mechanical engineer or civil engineer knows that the addition of those materials does not produce combustion but retards it? I could give numerous instances of United States patents similar in character which absolutely fail to realize their claims.

I will quote analysis of coal ashes made by J. A. Phillips, F. C. S.:

Silica	26.87
Oxides of iron and aluminum	56.95
Lime	5.3
Magnesia	1.19
Phosphoric acid	0.74
Undetermined	1.72
	100.00

Also analysis by Gautier, of France:

Silica	42.10
Aluminum oxide	34.40
Lime	4.80
Magnesium carbonate	0.40
Calcium sulphate	12.55
Iron oxide	5.28
	99.53

It is evident from these analyses that there is no carbon nor hydrogen in the ashes of coal, and without carbon or hydrogen we have no combustion; also that it will take more heat to burn these constituents than they will give back. In other words, "combustion of ashes" by the formula of the man from Altoona is due to the coal added and to nothing else.

THOS. B. STILLMAN.
Stevens Institute of Technology.

Will Not Increase Combustion of Anything

Professor Bellew, of Columbia University, is quoted as saying, when he was asked to give his opinion concerning the Ellmore formula:

"There is absolutely no potential heat stored up in ashes. To a large extent ashes represent only the clay and silt that got mixed some millions of years ago with the decaying, coal-producing vegetation of the carboniferous age. In ashes the combustible vegetation has all been burned out, and only the clay and silt left. So it would be just as logical to pour some of this wonderful formula on ordinary dirt and expect it to burn as to put it on ashes and expect them to burn.

"As for the formula itself, I can only say that so far as my chemical knowledge goes, there is nothing about it that would increase the combustion of anything."

Dr. Gill Calls It "Rot"

When such statements as these are published in reputable newspapers of our large cities, it would seem to be high time that we had a scientific press censor to prevent the people from being fooled. Statements like that quoted from the papers may perhaps be described as "pipe dreams," fairy stories, etc., but it seems to me that the short word "rot"—and I use it advisedly—is the proper characterization to be employed.

I have seen a number of recipes similar to this, having in addition an ingredient like Chili-saltpeter, which when heated hot enough will give off a little oxygen. None of these are of any value and all have been shown to be useless in a number of tests. This formula does not even have this advantage, as it contains nothing, nor can it make anything, that in any way will aid combustion. Possibly the water used may be of advantage with certain coals, as it is in railroad use, but that is all the merit I can see in it.

The explanation given of its behavior is utterly wrong and misleading, for soda lye cannot be produced by bringing common salt solution upon quick-lime even, much less upon coal ashes. It is difficult to see how by any possibility acetylene could be formed, using this formula, and if it could, the quantity produced from two ounces of oxalic acid, supposing all the carbon contained in it to be changed to acetylene (which it cannot), would be about 2/5 of an ounce, equal in heating value to a piece of coal the size of a hazel nut.

When this mixture comes into the furnace the fire appears brighter from the volatilization of the salt, which colors all the flames intensely yellow; this salt condenses on the cooler parts of the boiler and economizer and corrodes them. The oxalic acid is broken up by the heat of the fire into steam, carbonic acid, and carbonic oxide—all *products* of combustion, and, with the exception of the latter, valueless as fuel. The quantity of carbonic oxide produced is about 2/5 of an ounce, equivalent in heating value to a piece of coal the size of a pea. The effect of this can easily be imagined. Professor Fischer, the eminent German chemical engineer, said of all such formulas: "Such nonsense should not be patentable."

A. H. GILL.
Mass. Institute of Technology.

Audi Alteram Partem

THE COBBLER'S ANGEL CALLS A FOUL

H. K. HOY, M.D.
1425 TWELFTH AVE., ALTOONA, PA.
5/9/07.

"POWER"
New York, N. Y.
Gentn,

The Altoona *Times* handed me the Communcation of Prof. A. H. Gill which is to appear in your next issue.

Since Dr. Gill is like the rest of them harping upon a red headed Druggist's formula and not John Ellmore's at all, you will please in justice to John Ellmore also publish the inclosed clippings side by side with his. If this is not done the day may not be far off when there will be trouble. I hold now receipts from the Commissioner of Patents, F. I. Allen, receipts for first payment, and also for final payment on patent application of John Ellmore, and I certainly will not allow to go un-noticed malignments as to John Ellmore in the face of knowledge which I hereby give you, if patent is granted, which I have every assurance it will be, and may be within a few days.

Very kindly yours,
H. K. HOY.

Please take heed.

The inclosures consist of several newspaper clippings from Altoona newspapers, one calling attention to the fact that no smoke is seen coming from the chimneys of the Hoy mansion, owing to his use of the new process; another saying that Dr. Hoy has received a notice from Samuel Ryan, engineer of the Bellefonte water works, of a successful test given to the Ellmore ash-burning compound at that plant. Steam was raised in an hour and a half from a cold furnace, with the entire disappearance of ashes from the coal with almost complete elimination of smoke, and no slag left.

In still another F. Hoover, chief engineer, and William Taylor, fireman, of the Citizens' Ice Company, announce to whom it may concern that they made a test at the plant of that company occupying eleven hours on May 7, during which time there was used 3200 pounds of coal, which by the use of the Ellmore compound consumed all of its own ashes, excepting 75 pounds of slag. On the next day 4800 pounds of coal was used during the same time, and about six wheelbarrow loads of ashes were removed.

The other is a "gem," and we regret exceedingly that space forbids its reproduction entire. It is an unsigned "special" to the Altoona *Evening Gazette* of May 6. Its unknown author starts in by "taking a round" out of Dr. Lucke, of Columbia University, as follows:

"Since so many of the learned school teachers and intelligent school boys have taken it upon themselves, as a duty they owe to humanity, to enlighten their fellowmen upon the fallacies of the John Ellmore combustion proposition, permit the writer to say in almost every instance these aggregations of knowledge have barked up the wrong tree, since John Ellmore's formula has never been made public.

"One alleged school master who hails from the borough of New York, more 'Lucky' than the rest, has twice shown (?) 'the joker in Ellmore's ash-burning problem,'" etc.

It appears from this article that the cobbler has "been through" the patent office five times before.

"The claims for this discovery are, mainly, the conversion of combustible matter into fuel," says the unknown writer. This puts a new face upon the matter. We thought it was to convert incombustible matter into fuel.

"Has he ever, at any time, in any publication, advocated that an ash pile should be carted to the furnace and used as fuel? If he has, the writer challenges the production of that publication. John Ellmore has never, either privately or publicly, nor in any private or public test he has made, advocated nor used, nor advocated to be used, a greater proportion of ashes to coal than one to two in bulk. When this proportion is used the amount of carbon to the bulk of combustible material utilized, plus Ellmore's Chemical Compound, plus heat, is sufficient to convert the heating mass into a fuel product which upon scientific lines utilizes every combustible element present; leaving no residue, when the ashes produced are re-used, except a small portion of non-combustible matter which he denominates slag. The fine ashes all disappear. Where do they go to? In due time the scientist will give you the answer. John Ellmore does not know the answer and he don't care. He shows you the fact. You can see it for yourself. He shows the fact and proves the saving of the dollar, and these are the only things that interest him. He is the world's economist upon the fuel question. He can scarcely read or write, and yet he can make highly educated men listen in rapt attention, as at one time a poor Nazarene interested the wise men."

O, yes, there was one other clipping, an advertisement, from an unmentioned paper, of a $20,000,000 company with shares of $100 each. Persons desiring to subscribe will make drafts payable to John Ellmore and H. K. Hoy.

Shall we venture a prediction?

The only money that will have been made out of this burning ashes ripple, when in a month or so it shall have worked itself out, will have been made by the men who sell the stock, the newspapers that advertise the stock, and the manufacturers of oxalic acid in trial packages.

Comparative Tests

COPY. Syracuse, N. Y.
April 1, 1907.

The Nonesuch Button Works,
Balsac, N. Y.

Gentlemen:

At your request I have conducted competitive tests at your factory upon the so-called John Ellmore "Ash-fuel" mixture and upon Reynoldsville semi-bituminous coal, and beg leave to report thereon as follows:

BOILER TESTED:

The tests were made upon a 125 horse-power horizontal, water-tubular boiler, having

1253 square feet of heating surface and
30 square feet of common grate surface,

the boiler being connected to a chimney 30 inches diameter by 100 feet high.

HOW TESTS WERE MADE:

The "alternate" method of starting and stopping the tests, as advised by the A. S. M. E., was followed. The fuel used and water evaporated were weighed, the records being kept in duplicate.

All pipes not in use were blanked. Pressures and temperatures were taken at 15-minute intervals.

The fires were handled by your regular fireman, John Gethere.

FUEL USED:

The "ash-fuel" was a mixture of
1 part Reynoldsville coal at $3 per ton to
3 parts of ash taken from your old ash-dump.

RESULTS OF COMPETITIVE TESTS OF COAL AND ASH-FUEL.

Test number	1313	1314
Made on	Mar. 29, 1907.	Mar. 30, 1907
Duration, hours	10	10
Fuel	Coal	Ash-mixture
Barometer, in	29.94	29.86
Steam pressure, gage pounds	99.8	100.1
Draft at damper, in	0.45	0.41
Draft in furnace	0.23	0.22
Temperature of air, degrees Fahr	48	46
Temperature of fire room, degrees Fahr	71	72
Temperature of feed-water, degrees Fahr	199.8	200.1
Temperature of chimney, degrees Fahr	508	478
Amount of wet fuel used, pounds	5,387	3,894
Moisture in coal, per cent	2.8	....
Dry coal used, pounds	5,236	....
Ash and refuse, pounds	486	82
Ash and refuse, per cent	9.28	....
Dry combustible, pounds	4,750	....
Moisture in steam, per cent	1.10	1.05
Water pumped to boilers, pounds	46,732	47,326
Water evaporated, pounds	46,218	46,829
Equivalent water evaporated at and from 212 degrees, Fahr., pounds	48,621	49,264
Water evaporated at and from 212 degrees Fahr., per pound of:		
Wet coal, pounds	9.02	....
Dry coal, pounds	9.29	....
Combustible, pounds	10.24	....
Ash-fuel, pounds	....	12.65
Combined efficiency of furnace and boiler in utilizing heat, per cent.	63.87	83.10
Steam made by the 150 horse-power boiler as measured in boiler horse-power	140.9	142.8
Fuel cost of making 100 horse-power for 10 hours	$5.31	$1.04
Commercial saving by the use of the "ash-fuel" mixture per cent.	....	80.4
Smoke made as determined by the Ringlemann chart, per cent.	24½	7¼

The "ash-fuel" was a mixture of
1 part Reynoldsville coal at $3 per ton to
3 parts of ash taken from your old ash-dump.

(*Continued on page* 420)

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Calorimeters

A recent article in POWER by J. F. Boughton* criticizes the calorimeters now in use, because of the "calculations, corrections, deductions, etc.," which must be made in order to find what is being done. This raises the rather serious question as to the reliability of any instrument which does not make use of the refinements represented by such corrections. The fact should not be lost sight of that a very small quantity of coal is burned, the discharge of its heat going into approximately 2000 times as much water. Therefore errors in the combustion, which would be represented by a very small amount, are correspondingly multiplied in the final showing. As further evidence of this feature of calorimetric work, permit me to call attention to bulletin No. 94 (March, 1907) of the United States Department of Agriculture on "Investigations in the Use of the Bomb Calorimeter."

Here is a compilation of results on chemically pure combustibles by such authorities as Berthelot, Dulong, Favre, Silberman, Langbein, Stohman, Thomson and a dozen others, using the very extremes of refinement covered by the terms "corrections, deductions and calculations." With all possible precautions these observers disagree among themselves upon pure substances to the following extent:

Carbon with variations of 4.33 per cent.,

Sulphur with variations of 4.33 per cent.,

Cane sugar with variations of 6.43 per cent.,

Benzoic acid with variations of 1.25 per cent.,

Naphthalene with variations of 1 58 per cent.

These figures are not a little disturbing to our ideas of accuracy, even where methods of extreme care and utmost detail are employed. What shall we say, then, of the comparatively crude method offered by Mr. Boughton?

By way of illustration, sugar carbon, as described in the article under consideration, might retain a very considerable amount of hydrogen. For example, 1 per cent. having four times the heat equivalent of carbon would represent an error of approximately 4 per cent. If higher heat is applied, and the amount of hydrogen reduced to a minimum, the resulting product will be exceedingly difficult to burn with sodium peroxide alone, from 2 to 6 per cent. of the total being possible residue.

Another question should be raised concerning the method of grinding and mixing the coal and peroxide in the open air. This material has a remarkable avidity for moisture, forming thereby the compound $Na_2O_2 \cdot 2H_2O$. In combustion this compound re-combines with evolution of heat, forming sodium hydroxide and oxygen.

Equally serious would be the errors that would result from the attempt to make the apparatus serve as its own thermometer. Occluded gases and air that is certain to cling to the sides and corners of the vessel will have an expansion quite at variance with that of the water. At the time of ignition the reaction will be so marked as to cause the water in contact with the inner receptacle to boil, thus throwing into the upper part of the space an amount of water so high in temperature as to accentuate the expansion of air particles, and also accentuate the variables due to radiation. The increase of air particles by $\frac{1}{1000}$ of a cubic inch would represent approximately one division on the scale, or 1 per cent. of error.

As to radiation, under favorable conditions, with a stirring device that maintains a temperature at no point greater than 3 or 4 degrees above that of the surrounding air, it is not uncommon to lose an amount of heat by radiation over a space of 5 or 6 minutes, which, if not corrected for, would result in an error of 1 per cent. How much more pronounced, therefore, would be the possibility of loss where the extreme of heat in the upper part of the apparatus might reach 15 or 20 degrees above the surrounding air?

To anyone who has had much experience in such work, it is disappointing that the description covering the manipulation did not go one step further and detail the method of passing from one test to another. Of course, manipulations of this type, where variables enter in to so great an extent, must be made in duplicate, and at any rate many samples may be on the list for continuous running. It is inconceivable that the same water is retained in the vessel and used a second time with the added increase of temperature, for by such procedure no two results could be in accord. Equally difficult is it to understand how the apparatus could be emptied after each operation and, with any degree of facility or accuracy, brought again to the same zero point without introducing certain variables, especially in the way of air particles, which would vitiate the comparison.

These are but a few of the difficulties that are evident from the description of the device. Others would involve a wider range of discussion. With sodium peroxide alone, the combustions of coal are not complete, and not consistent in extent. Coals also differ as to their amount of combined water. This constituent is not removable by drying, and has no counterpart in the sugar carbon. It has its own heat of combustion quite independent of any heat inherent in the coal as a result of its combustion. Disregard of this fact will in itself result in an error for bituminous coals of from 1 to 2 per cent.

Another criticism on this phase might be entered, which is done with some hesitation, because it involves matters more or less personal to the writer. The constituents of coal that enter into the reaction with sodium peroxide are carbon, hydrogen, sulphur, water and ash. Now these elements are widely variant in their fuel values and, moreover, cannot pass through this reaction without producing heat wholly apart from that represented by their simple heat of combustion. To say, therefore, that a pure element, or a supposedly pure element, like sugar carbon can be used as a parallel and standard of comparison to so complex a substance as coal is to presume upon facts which do not appear in the description under discussion.

More explicitly, the problem is this: Hydrogen burns to H_2O; carbon burns to CO_2; sulphur burns to SO_3; constituents already exist in coal as H_2O. But $H_2O + Na_2O_2 = x$ calories, $Co_2 + Na_2O_2 = y$ calories, and $SO_3 + Na_2O_2 = z$ calories.

Can these complexes represented by x, y and z be referred to sugar carbon as a standard? To what extent they may be correlated and wherein they are at variance is the very essence of the method devised by the writer, and now in very common use throughout this country and in Europe.

The establishment of the principles involved has been at an expense of time and research almost beyond computation, and it is hardly to be expected that the appro-

*September, 1906.

priation or misuse of the facts so gained can be allowed to pass without protest.

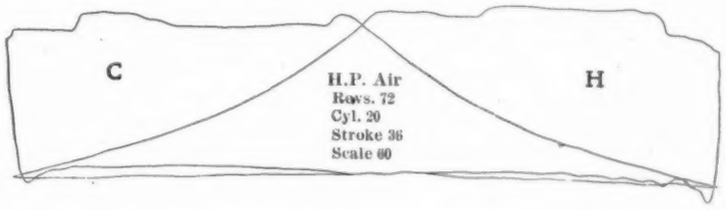
A most exhaustive study of the properties and reactions of sodium peroxide as a combustion medium has demonstrated its value when properly used, and has also served to accentuate the importance of care in those conditions quite generally disregarded in Mr. Boughton's device. It would be unfortunate to discredit the general process by a method so full of possible errors.

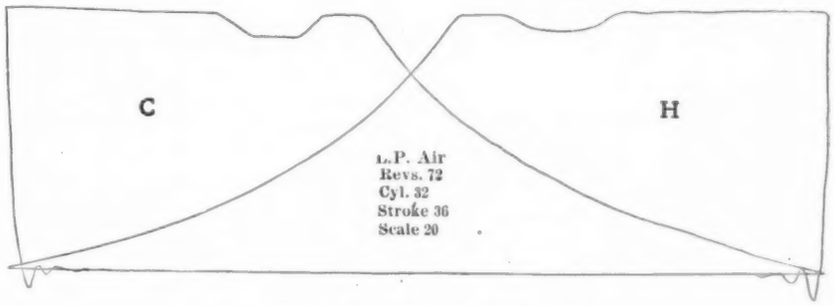
S. W. PARR.

Urbana, Ill.

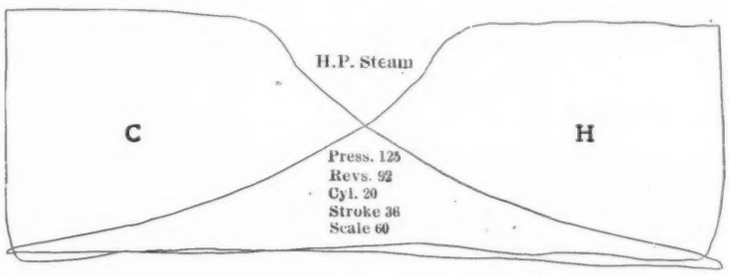
Corliss Engines in Coal-mine Work

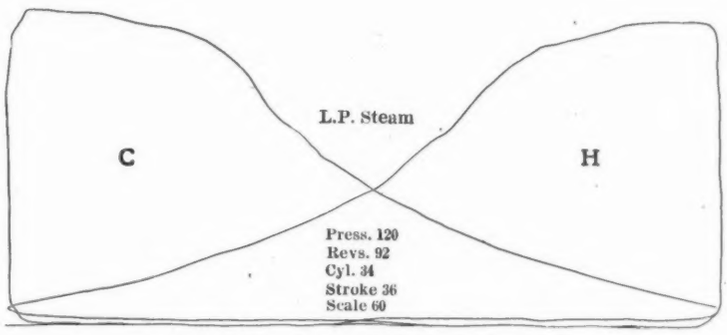
It is only in recent years that the more economical Corliss steam engine has been installed by soft-coal mine operators. One reason for this is that considerable unmarketable coal comes from the mines, which is burned under their own boilers. Another reason, which is, perhaps, a larger factor in the case, is that few operators realize the saving effected by the Corliss engine, where compounded, over the more common type of straight-line, engine-driven air compressors.





DIAGRAMS FROM THE AIR CYLINDERS





DIAGRAMS FROM THE STEAM CYLINDERS

The power cost of compressing air for use in most soft-coal mines is much in excess of other power required, and when two-stage compression is desired, the cross-compound Corliss steam engine provides an ideal means for motive power, i.e., where steam is used.

The Buffalo & Susquehanna Coal Mining Company has installed at its Onondaga (N. Y.) plant two cross-compound Corliss engine-driven, two-stage air compressors, with dimensions as follows: Steam cylinders, 20 and 34x36; air cylinders, 32x20.

The air cylinders deserve especial mention, as they are of comparatively new design, calculated to reduce the clearance to the minimum. How well this has been accomplished may be seen by the accompanying diagrams. The diagrams from the air cylinders were taken with rather long pipe connections, with angle valves at the ends, and the indicator was connected by a straightway cock to a tee about midway between the valves, the section of piping being a little longer on the high-pressure cylinder. The diagrams were taken simultaneously, but as one of the indicators could not be attached to the threeway cock the steam diagrams were made separately, with the conditions otherwise as nearly alike as possible. All air-inlet valves are of the Corliss type, and the discharge valves are of the poppet style for both cylinders. The high-pressure steam and exhaust valves are operated by one wrist-plate, while the low-pressure valves are operated by two eccentrics. The maximum speed is 92 revolutions per minute, and the average speed at present is about 65 revolutions per minute.

Parenthetically the writer would like to say that, while he thinks the diagrams are fairly good, they are not presented so much on account of their excellence as in the hope that they may prove of interest to those readers who are using air compressors.

These machines have given very little trouble; one compressor has been running more than fifteen months, and has not cost a cent for repairs, except to renew two vulcanite washers in the high-pressure air valve-stems, and for dash-pot plunger leathers, which were made in the compressor room. Also the machine has run this length of time without a hot bearing.

The cost of lubricants for the months of September, October and November, 1906, was on an average less than fifteen dollars per machine. This included all lubricants used, and they were applied without the aid of an oil filter.

P. A. STAFFORD.

Dubois, Penn.

Crooked Rivets in a Fire-box Boiler

Herewith is a photographic sample of a slovenly riveting job in a fire-box boiler which I had to repair. The way some of the rivets had been driven was startling, to say the least. I also inclose a sketch to show how the rivets were headed. To speak plainly, I call it a rascally, slouchy boiler job.

Referring to the drawing Fig. 1, it will be seen that the rivets were headed crooked and that the metal flowed to one side, leaving the other side with no calk-

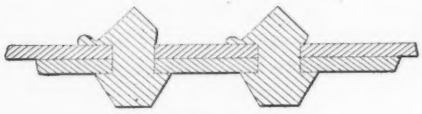


FIG. 1

ing edge. While there was no leak where these particular rivets were placed, there were joints on the boiler that barely could be kept from leaking and that had to be calked frequently. These bad rivet heads did not appear uniformly throughout, but were found here and there. They were somewhat out of line and as the work was done by an hydraulic machine, probably, that would account for the heads being closed over sidewise.

Fig. 2 plainly speaks for itself, and there is no telling how many more rivets like it, or worse, may have been in the boiler. It indicates that the holes were not fair and had not been reamed. From the appearance of the holes, too, I should judge

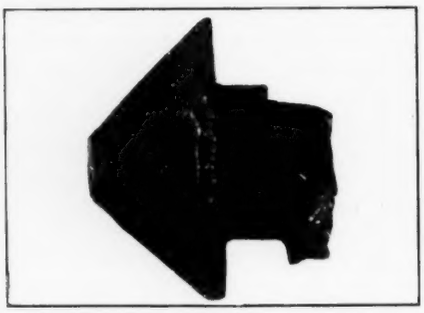


FIG. 2

that the drift was not used either. I had a "nice little time" getting some of these rivets out, but by cutting the heads and resorting to the drill it was accomplished.

There is urgent need of careful inspection, not after a boiler is built and put into commission, but when it is being built, as a little carelessness then makes a dangerous later condition which is too easily covered up, and which never comes to light, perhaps, unless the boiler explodes, or is otherwise destroyed.

E. L. T.

Oregon City, Ore.

"Loose Nuts and Narrow Escapes"

The trouble described by Mr. Wakeman on page 161 of the March number would be proved to be a common occurrence if every engineer who has this type of engine in charge were to speak up. Considering the serious results likely to follow this kind of failure, a device for securely locking these parts would be very much appreciated. On slow-speed engines there is usually ample warning from the time the piston first strikes the head before any damage is done, but the writer has had the same experience on a high-speed engine where the piston unscrewed so fast that we had a very narrow escape.

The nut which holds the piston seldom has to be removed and the rod can very well be partly upset a trifle to keep this nut from backing off; but such is not the case where the rod screws into the crosshead. This joint has to be taken apart on many occasions, and this is so easily done, and with the present arrangement allows of such nicety of adjustment that the construction would be an ideal one if it were not so liable to work loose. I have seen set-screws resorted to, but they are objectionable for obvious reasons, and the only safeguard seems to be to try the nut once in a while to make sure it is tight.

R. CEDERBLOM.

Chicago, Ill.

Effect of Compression on Cut-off

Referring to his letter on page 315 of the May number, Wm. Westerfield evidently misunderstood my meaning at one point. He quotes me correctly in saying: "With the same engine and the same cut-off, when the compression is high the cut-off corner will be rounded." Regarding this he makes the comment: "The cut-off corner being 'rounded' is due to speed and not to the point of cut-off." If he will go back and read it again he will note that I said: "When the compression is high the cut-off corner will be rounded."

Twenty-five years ago, when I was working on the double-eccentric "business," I stumbled on to the above. My idea of two eccentrics was to get a longer range of cutting-off and an early release, with compression as incidental. The first two came all right, but on increasing the compression I was somewhat surprised to find I lost the sharply defined cut-off; and the more the compression was increased the worse this became. This engine was 28x60-inch, running at 52 revolutions per minute.

Mr. Westerfield makes the correction that with a high compression the cut-off will not be the same, and I agree with him; and I will make the statement, based on my obversation, in another way: With the same engine and the same load, when the compression is high the less distinct will be the point of cutting-off, and the higher will be the terminal pressure. Should Mr. Westerfield wish to change this to read that with high compression the cut-off will be later, I will agree with him; but he will also find that it will destroy a clean cut-off. I have not been able to explain why, but I know that it is so.

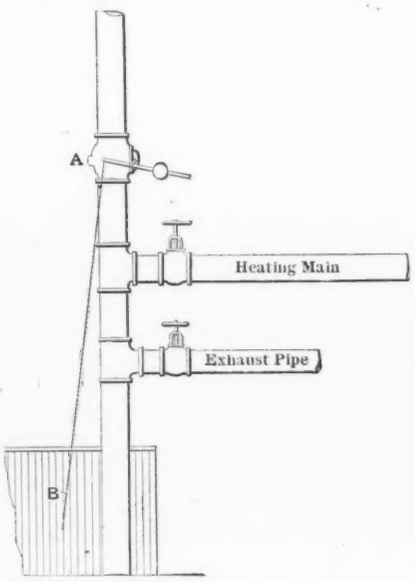
W. E. CRANE.

Boston, Mass.

"Weighting a Back-pressure Valve"

Apropos of the discussion of this topic started by Mr. Wakeman, in November, and replied to by Mr. Schneider, in May POWER, back-pressure valves are usually located at a hight which requires a ladder to reach in order to operate them.

I submit herewith a sketch which shows



MR. SHERIDAN'S DEVICE FOR WEIGHTING BACK-PRESSURE VALVE

a simple means of adjusting the weight. At *A* a hole was drilled in the end of the lever, and a chain attached, so that when steam was not used for heating, the valve could be opened by pulling down on the chain, which was held by a hook at *B*. The ball was made fast on the lever by means of a set-screw, at a point determined for operating at two pounds back-pressure. To close the valve it is only necessary to release the chain at *B*, or the valve may be left partly open, when using exhaust steam, adjusting the chain.

JAMES G. SHERIDAN.

Brooklyn, N. Y.

Closing in Side Walls

The brick setting of a pair of 84-inch by 18-foot horizontal return-tubular boilers, set together as shown in the photographs, cracked badly when the boilers were fired up. The boilers were supported upon I-beams carried up on columns by means of four U-bolts extending from the beams to pads riveted upon the shells. The photographs show this arrangement also. The brick walls were independent of the structure and carried nothing but their own weight. When the boilers were fired up, both side and rear walls cracked, not in the ordinary zig-zag way, but in straight lines following one course of brick upon a level with the center of the boiler.

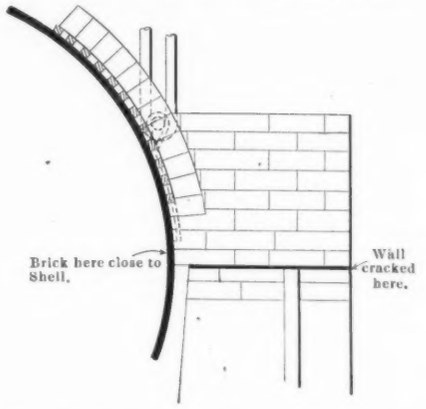


FIG. 1. HOW WALL WAS LAID TIGHT TO ARCH

Upon inspection we found the inner walls intact. They were lined with fire-brick, well bonded with a row of headers at every fifth or sixth course. But when I tried to shove my rule up along the side wall between the shell and the boiler, it would not go any further than to about the center of the boiler, showing that the bricks were laid close to the shell. We found this to be the case for the entire length of the side walls. At the rear of the setting we found ample space allowed for the expansion of the boiler lengthwise; that is, there was about an inch and a half between the rear head and the back arch, but on the side the bricks were closed in tight to the shell, and the boiler in expanding had simply crowded the wall out and cracked it on this line.

It was decided to tear out the side walls down to the center line of the boiler, both side and rear, and lay them over again. The boilers were covered in by a layer of brick laid upon lagging, as shown in the engravings. And as the work was torn down, we saw that this arch was carried down below the side walls, and that the wall was laid tight to the arch, as shown in Fig. 1. When the boiler was heated and stretched under pressure, the expansion had to go somewhere, and it was evident what had caused the crack. It was found that the back arch had been raised and broken away from the rear wall, as shown in Fig. 2. When the ends of the arch T-bars were uncovered, it was found that they had been bricked in solid, and when they became heated they had simply jumped up and carried the arch up with them. In rebuilding the setting and closing in, the fire-bricks were laid about one-half inch clear from the shell; the upper corner was chipped off and a rope of asbestos about an inch in diameter laid around, as shown in Fig. 3. This removed any touch or tie between the boiler and the wall, while making a fairly tight joint. The wall was then carried to the proper hight, and at each course a space was left between the shell and the brick. When the pads were reached, they were also left free, so that when the wall was finished there was not a single brick in contact with the boiler.

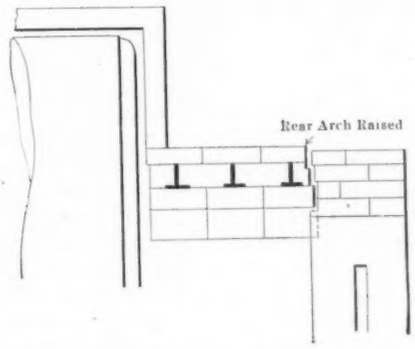


FIG. 2. HOW BACK ARCH BROKE AWAY FROM WALL

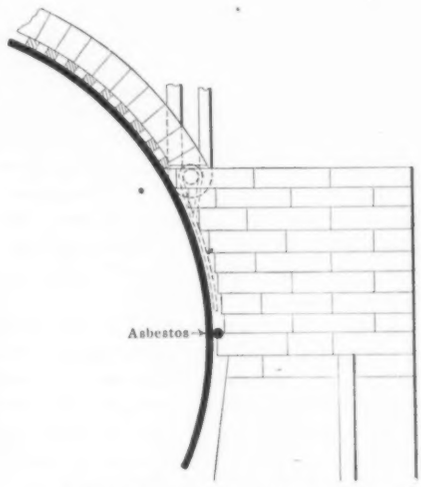
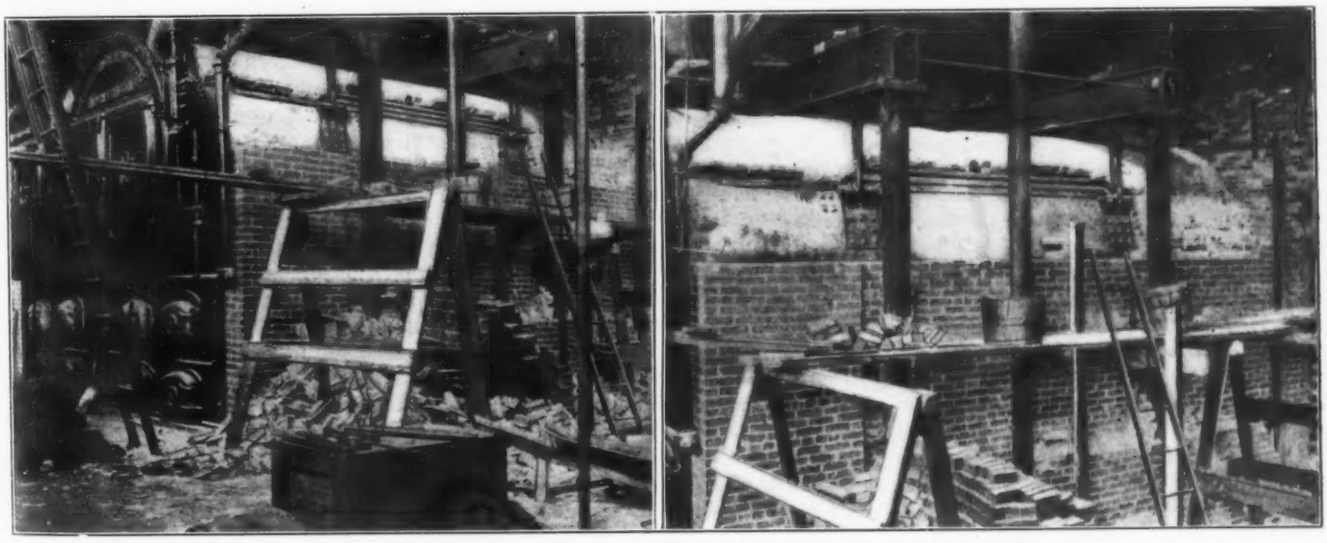


FIG. 3. HOW SETTING WAS REBUILT

The brick arch which covered the top was next replaced, and where it joined the side wall the bricks were laid on top, as shown in Fig. 3. In this way the arch can expand without crowding the walls. The ends of the supporting part of the rear arch were left entirely free by arching them over with brick, and as the expansion would follow the line of least resistance, the ends being free, the arch could not raise.



SHOWING THE BRICK SETTING OF A PAIR OF HORIZONTAL TUBULAR BOILERS

W. F. SARGEANT

New Haven, Conn.

Ammonia Compressors and Some of Their Defects

Many tests by experts of ability have conclusively demonstrated that the actual work done in the compressor falls short of its theoretical amount by from 20 to 50 per cent., and this is accounted for by the fact that the cylinder does not fill on the inlet stroke with a full charge of cold gas having the density of that in the expansion coils, and it is explained by the fact that the gas is heated and expanded by coming in contact with hot cylinder walls, and is also retarded and further expanded or rarefied by the work of lifting the suction valve.

In air-compressor practice it was long ago discovered that it paid to operate the suction valves mechanically, even at the low pressures used; then why not all the more necessity for so doing in ammonia pumps working under pressures much higher?

As to the re-heating, it is well known that ammonia gas is very susceptible to heat changes and will expand rapidly on receiving a slight increase of heat. It is therefore most important to take the gas into the cylinder as *dense* and as *cold* as possible and to keep it so until the compression begins. Now as the incoming gas is at a temperature of about zero, is it not poor engineering to surround it with jacket water some *sixty* degrees *hotter* than itself? Keep the inlet end of a single-acting pump as cold as possible and note the result.

Then in single-acting pumps why retain that superfluity, the false head, to act as an interchanger of heat? This mass of metal, not being in contact with jacket water and being surrounded on all sides by hot gas, gets very hot, as many who have had occasion to remove one in a hurry know too well. In this condition it serves well as a re-heater to the gas coming into the cylinder.

At the moment of compression, the volume of gas is in the form of a disk with little area on the periphery, but with a comparatively large area on the flat circular sides lying against the cylinder head and the piston. Cool this surface and note the effect.

Then the stroke of the compressor, why should it not be long and slow? Long to reduce the percentage of clearance and slow to allow time for the heat to dissipate to the cooling water.

In the best steam-engine practice high piston speed prevents loss of heat by radiation, then why should not an ammonia pump be run slowly to assist such radiation, which in this case is desirable?

Taking up the double-acting horizontal compressor, what do we find? Generally a very short stroke to begin with. Then the admission of cold gas through a small hot-valve passage to a cylinder heated to the limit by the last charge of compressed gas, and then the usual water jacket. To make it possible to run this machine at all the wet system is resorted to or a little liquid ammonia is injected into the cylinder to cool things, thus doing a certain amount of work twice, which might as well be avoided.

F. A. RIDER.

Pittsburg, Pa.

Effect of Rope Drive on Fire Risk

After the disastrous fire, which on January 27 last caused extensive damage in the Cocheco mills, at Dover, N. H., an important point brought out was the increased danger of fire due to openings in the mill flooring, to permit the passage of driving belts. This mill was driven by two engines, the fly-wheels of which were inclosed in a wooden housing. Driving belts passed through the brick walls in openings about 8 inches wider than the belt, and allowing 6 inches clearance above and below it. The origin of the fire is ascribed to the breaking of an automatic sprinkler above one of the belt housings. It is believed, according to John R. Freeman, president of six important mutual insurance companies, who reported on this fire, that the broken sprinkler wet the belt, which, slipping and sliding sidewise, chafed against the wooden housing and frictionally ignited it. Once started, the fire quickly spread over the cotton on the machinery work, and passing through the large belt openings, spread through the floors. The brick walls and heavy plank and timber floors, which normally should have confined the fire to the immediate space in which it broke out, were useless as protectors on account of the fatally large holes cut to permit the belts to pass. Owing to the slipping of belts, causing them to oscillate violently at times, it was necessary to make these holes with large clearance spaces to prevent destructive abrasion against the sides of these openings.

This points to the superior advantages of rope driving over belting, as a means of transmitting power to different floors of a mill or factory. If rope drives were used, the main shafts could be carried through the wall on each floor, and provided with outside sheaves, the outer shaft ends being supported by end bearings securely mounted on struts secured to the wall, or pillars rising from the ground and stayed to the wall. Such an arrangement would entirely do away with the necessity of any openings in the floors or walls, keeping the floors tight, so that fire could not quickly pass from one to another, if for any reason the sprinklers do not hold it. In addition to the diminished fire risk, this construction affords great saving of room, increases the clear overhead space, and lessens the obstructions to light. Belting could not be used for outside driving, because it is quickly affected by rain and changes of weather, but with properly lubricated rope such drives can stand for many years with little attention beyond occasional tightening up. To secure "weatherproofness," transmission rope must be internally lubricated with some material not subject to decomposition by heat, nor liable to be washed out, and which, upon working to the outside in use, will form a coating of smooth, glossy material absolutely impervious to rain.

Transmission can be established in the same manner between shafts in direct vertical line or at any angle of obliquity, and there is practically no limit to the power that can thus be transmitted. In case it is preferred to keep the transmission within doors, rope drives still offer very much more safety, as far as fire risk goes, than belt transmission. The holes required are very much smaller and need practically no space for clearance. Often a rope is carried vertically through several floors in a small round casing, which looks like one of the supporting columns or pillars of the mill construction. There is no possibility of the rope slipping sidewise, as did the belt which caused the Cocheco fire, because it is held firmly against lateral motion by being wedged between the flanges of its sheave. From every point of view, rope driving commends itself to the manufacturer who wishes to reduce his risk of fire, and especially to the fire insurance underwriter in apportioning the premiums required for different devices.

Where belting is used for power distribution between floors, it is almost unavoidable to break up the transmission into successive steps or stages, as a belt run from the ground floor to the third or fourth story of a mill would have too much sag, besides costing a prohibitive sum and necessitating a whole series of openings, two in each floor. The usual method is to transmit all the power to the first floor by one belt, thence to all the floors above that one by a second belt, and so on. If the first-stage belt should break or need adjustment, the entire mill is at a standstill. In rope driving, separate transmissions are carried from the main driving sheaves on the ground floor, or in the outhouse to the main shafts of each floor. As these are usually run on the multiple system, a number of independent ropes being carried for each transmission, they practically shut out the possibility of breakdown of even one floor, because each rope is run at but a small fraction of the tension it can stand, so that if one or more ropes should part, the others of that system can easily carry the load until it is convenient to reeve off new ones or splice the old ones. But remote as is the chance of breakdown of power on one floor, it would at the worst be confined to that floor, as all the others are independent of each other. Hence, there is no danger of

completely removing the load from the main drive, which so frequently causes the driving engine to run away with disastrous results to fly-wheels and operating parts.

A. HARTRATH.

New York City.

"The Influence of Central-station Loads on Smoke Production"

The article on the above subject, by Dr. Chas. E. Lucke, in the March number of POWER, page 150, is extremely interesting because it raises several novel points, as well as emphasizes the fact that a variation of load may cause smoke. I will not discuss the cases where smoke is produced on account of an increase in the load on a station, because in such cases the smoke may be due to an insufficiency of design of furnace; that is to say, the furnace may be of such construction that the amount of fuel it is being called upon to burn will be greater than can be properly dealt with under an arch of a given length, within a combustion chamber of a given capacity, or with an air supply above the fire admitted through a given area of opening of the register in the door. So far as my personal experience with ordinary English bituminous coals will carry me I would state that under ordinary fair conditions, with steady loads, the area through the door grids or registers requires to be made not less than four square inches per square foot of grate surface. But a fruitful cause of smoke is when an endeavor is made to reduce the steam-making capacity of the furnace to suit a reduced load. It is on such occasions that large volumes of smoke will be made, much to the surprise of those who have allowed themselves to believe that smoke preventing or production is entirely a matter of easy boiler working, or the reverse.

On the contrary, an easily worked boiler may be a producer of very much more smoke than the same boiler worked more strenuously. Observing this fact, there are others again who lay down as a law that a boiler must be worked on a good draft, or it will be smoky. Now, both views are partial only and not based on an appreciation of the whole of the circumstances of the problem. Draft is a very curious factor, and it is not right to say that a boiler has a good draft, or that it has a poor draft, and that therefore it will produce smoke, or it will be clean. Draft with anthracite may perhaps be a simple item, properly to be regulated by the chimney damper alone. I say "may be," because it seems to me that where anthracite is burned it may often happen that the volume of air admitted through the grate will be insufficient for perfect combustion. Therefore there will be a certain proportion of carbonic oxide produced in the furnace, and this will not obtain sufficient air for its complete reduction to dioxide, and there will be loss in consequence. If the layer of fuel on the grate be very thick, it is certain that the air passing up through the fuel will be completely deprived of its oxygen, and carbonic oxide will most assuredly be produced.

The question would now arise, how could sufficient oxygen be admitted in order to burn this monoxide and get full value out of the fuel? Let it be assumed that we endeavor to effect this purpose by means of a wider opening of the chimney damper. The result will be a more brisk combustion of fuel on the grate, and a larger production of steam, which is not what we want, and it would still be doubtful whether the greater volume of air now drawn through the fire would not be converted as before into monoxide, with the loss of efficiency as before. Clearly, what we want to do is to introduce air to the monoxide gas, so as to burn this without increasing the combustion of the fuel on the grate.

Indeed, if we succeeded in burning the monoxide, we should treble the amount of heat generated, and could then reduce the amount of fuel necessary to be burned to one-third what it had been. With ordinary chimney damper regulation it is quite obvious that one cannot vary the air supply below the grate without also varying that above the grate. It is not possible to admit the proper amount of air to the gas generated on the fire and also properly control the rate of combustion on the grate. In ordinary practice with anthracite the difficulty is usually surmounted by maintaining a fire so thin that sufficient air can pass through the fire, uncombined with carbon, to burn the monoxide gas that is produced by the furnace. A thin fire admits at once more air and tends to the reduction of the monoxide formed. If the fireman can discover just what this thickness is he will get the best result from his fuel. But when the load varies he never can be sure of the best thickness, and as Dr. Lucke says, anthracite has peculiar difficulties of its own. Still, the foregoing will enable one better to apply a similar reasoning to the question of bituminous coal combustion.

With bituminous coal, no matter how rapid may be the rate of combustion per square foot of grate, if green coal be thrown upon the surface of the fire it will throw off most of its volatile gas within a few minutes after it has been fired. Such being the case, it follows that the volume of air necessary to burn this gas must be supplied in a given time almost irrespective of the strength of the draft. This is where trouble commences. Let us assume that in a given furnace the conditions are right for a given load. The air grids in the door are correct in area for the draft necessary to drive that load and supply sufficient air to mingle with the gases from each change of fuel. There is, in fact, smokeless combustion under a given, and, it may be, fortuitous, concourse of circumstances. Then the load alters; it is, let it be assumed, very considerably reduced. Less steam is required to be made, less heat is wanted; less coal must be burned. The proper thing to do is to reduce the grate area, but this is not practicable, since in a few minutes or hours, the conditions have all reverted to what they were. What is usually done is to lower the damper in the chimney end of the flues and thereby reduce the volume of air flowing through the grate. Trouble at once begins; smoke is made and inquiries are set on foot with the object of preventing it.

We have already been brought to see that air regulation cannot be brought about at two places by means of the chimney damper. If checked under the fire, it will be checked over the fire. What is it we really want to do? In the first place, we must burn less fuel in a given time, because we require to manufacture less heat. In the second place, we must contrive to mix air with the gases driven off at each fresh charge. It is quite true that we may now be charging less frequently, but we shall continue to charge the same quantity at each firing period, and we must supply the air above the fire in the same volume as heretofore, and this is quite inconsistent with the reduced draft of air below the fire.

With a chimney damper we are, so to speak, in a dilemma, for we are trying to do two opposite things with one damper. To be brief, we must change our methods. We must continue to leave the chimney free to "pull" into the furnace above the fire nearly as much air as before, in order properly to deal with the volatile gases. But we must cut down the air supply below the grate, so that less solid fuel may be burned at any one time. This cannot be effected by means of the chimney damper. It is only possible with a damper so arranged as to cut off the supply of air to the hearth pit without interfering with the supply above the fire. And this may very easily be arranged either with water-tube boilers or with the internally-fired boilers so much used in Great Britain, or with the plain cylinder return-tubular under-fired boiler.

All that is necessary to be done is to supply a damper-plate or door to shut off or regulate the flow of air to the ash-pit or chamber below the grate.

Then the chimney damper should be arranged with a stop that will prevent it from being shut more closely than will permit, at all times, of the supply of sufficient air through the firing doors above the fire level. This will insure that the chimney draft will at all times be sufficient to draw in the air necessary for the combustion of the volatile matter from each fresh charge of coal. The rate of

combustion of the coal on the grate must then be adjusted to the demand for steam entirely by the regulation of the new damper which closes the ash-pit. No matter how closely this may be shut, there will always be ample draft to draw in the air above the fire when the fire-door register is open. Needless to say, though conditions are so far correct for smoke prevention, it is hopeless to think that smoke will be prevented unless the air which enters the furnace is enabled thoroughly to mix with the gases by passing over the length of the furnace. Then the temperature of the mixture must be maintained by means of a sufficiency of fire-brick linings and walls, or bridges so arranged that the gases may not be exposed to the chilling influence of water-cooled plates and tubes before combustion is sufficiently complete.

In English practice the fire door is usually lined with a perforated plate, the idea of which is that the air passing through it will thereby be presented to the furnace in fine streams, the better to mix with the gases. Personally, I place the greatest weight upon the proper use of the ash-pit damper, and in the course of lectures given by me to engineers and firemen, under the auspices of the London Coal Smoke Abatement Society, just before leaving for New York, I laid particular stress upon these dampers, for I have so frequently encountered cases of smoke that have arisen from poor draft due to what is the same thing as an insufficient chimney, namely, a nearly closed chimney damper. Everyone recognizes that an easily worked boiler is economical; everyone also realizes that one must have a good draft. The two appear to be incompatible, but the ash-pit damper is the solution of the problem, for it enables a large grate area to be worked with a low rate of combustion and renders unnecessary that reduction of grate area which is so often carried out the better to fit the draft and the demand for steam. It should not be forgotten that the admixing of air at the fire doors should be shut off by the door registers when the volatiles have disappeared.

W. H. Booth.

New York City.

To Prevent Sudden Pressure Acting on Gages

On page 317, May Power, J. W. asks if there is a remedy to prevent sudden pressure acting directly on the gages on high-pressure hydraulic pumps. I would make the gage pipe 10 feet long, if possible, put a globe valve at each end, and throttle both valves.

W. E. Crane.

Boston, Mass.

"Should Lignite Be Wet or Burned Dry?"

Referring to Mr. MacGregor's question as to whether lignite should be burned wet or dry, I am of the opinion that it will give better results if it is kept dry. I have burned a great deal of lignite, and I have noticed that it gives more or less trouble when wet. It seems to clinker and give out less heat. Of course, different conditions produce different results and it is possible that he can get better results by wetting it than by burning it dry.

W. F. Burrow.

Hico, Texas.

"A Case of Demagnetized Field Magnet"

I was very much interested in the account of Mr Doughten's demagnetized field, on page 250 of the April number, and the replies in May. While I believe that a badly designed armature giving excessive back-ampere turns was the root of the trouble, I think that a study of the conditions will show that the direct cause was an oscillating current of electricity which was set up in the shunt field coils, when the main switch was opened. If the matter is analyzed it will be seen that there was an electric pressure that had its source in the armature, and as long as the main switch was closed and there was a load on the circuit, the current had two outlets, one through a highly inductive circuit (the shunt field coils), and the greater portion through the external circuit. Now upon opening the main switch the only course possible for the current to take was through the shunt field coils, and as the output in amperes through the armature was suddenly reduced, the counter effect of the back ampere-turns of the armature was thus suddenly removed, and therefore the reluctance of the magnetic circuit reduced, thus allowing a variation in the flux. Since inductive circuits have properties similar to the law of inertia, which states that matter tends to react on forces acting to change an existing state of rest or motion, this variation in flux was resisted by a counter pressure set up in the field coils, and as these coils still had a closed circuit through the armature, it is possible to conceive of a current of an oscillating nature being thus induced, which, it is readily understood, would demagnetize the core of the magnet.

This effect of oscillating currents becomes a very important matter to those in charge of the operation of high-tension, long-distance transmission lines, where the wires have a high electrostatic capacity, as by opening the circuit at certain points these oscillating effects, added to the pressure of the line, may cause serious rises in voltage and endanger the insulation of the circuits and connected apparatus.

Charles J Seibert.

Brooklyn, N. Y.

Modified Sweet Valves — Thin Piston Heads

Numerous tests have shown that of the many engines in which the Sweet flat balanced valve is purported to be used very few really carry out Professor Sweet's ideas to the letter. As a rule, while many such are what may be termed "modified Sweet valves," it is hardly a compliment to the well-known inventor to call some of them by that title. Recently a test was made of one of these valves, constructed for and working under 160 pounds pressure, admitting steam to a cylinder in which the piston speed was 900 feet per minute. Examination showed that the valve ends were narrower and the valve had a much shorter lap and travel than a Sweet valve; therefore it will not wear as long, is more likely to leak, and it cannot be as effectively lubricated. In fact, after three months' careful operation of a similar engine it was found that the valve leaked badly.

I remember inspecting a large engine which was intended for the Chicago World's Fair, but which was not delivered, because, as I was later informed, the valve did not have travel enough to wear right. Recently, too, I saw in a catalog a so-called Sweet valve with short travel, but this is a modification not intended by Professor Sweet. The idea of a valve with a long lap and plenty of travel is a good one; the reverse is bad, for on a balanced valve the more surface there is the longer it will wear and stay steam-tight.

Not long ago I got some fine indicator diagrams from an engine using a Sweet valve (modification), with a travel of six inches and port width of one inch. The steam pressure was 160 pounds and the piston speed 900 feet.

Another thing I think builders should avoid is a thin piston head with only slight spacing between the rings. It is frequently done for want of room. The better way would be to have a thicker piston head, to provide more wearing surface and allow the head to water-pack between the rings. I built a 12x12-inch automatic engine with a piston head eight inches thick. After being run constantly day and night, six days a week, for six years, it was in almost perfect condition. Of course this construction costs more.

C. R. McGahey.

Atlanta, Ga.

More Comment on the Wood Worsted Mill Plant

The article on "The Steam Plant of the Wood Worsted Mill," in February POWER, and the discussion which it brought forth, have been very interesting to me, especially Mr. Diman's letter on page 250 of the April number. Mr. Diman says he has no water tender. Of course, it is possible to dispense with the water tender, but I consider him an essential feature of a successfully operated boiler room, and I know that a water tender will save his wages several times over. However, it is just as easy to dispense with him in the water-tube plant as in the return-tubular plant.

It is admitted by Mr. Diman that it takes eight firemen for twenty boilers for one shift; also, five coal men for twenty boilers for one shift. Mr. Diman only allows one boiler washer for twenty boilers for one shift, but in the water-tube plant I would still stick to four, as I believe this is an important item that makes for fuel economy, as well as long life for the boiler. Two ash men are allowed for the twenty boilers for one shift. (This is one more than was allowed in the original article and is probably due to the large piles of ashes that have evidently accumulated in front of the "poor cuss," as shown in the photograph on page 79.)

The original article stated that on account of the "large investment involved in carding and combing machinery, it is desirable to run these departments continuously."

Nothing is said about how much work is done at night, but one is led to infer from the original article that at least a part of the plant is run at night, so we will put the night shift at one-half the day force.

While making these corrections in the number of men required to operate the plant, based on the original article, I will also correct my own statement about the life of the plant and make it twenty years, instead of fifteen, as suggested by Mr. Diman. Assuming the entire plant to be installed and in operation, then, and assuming the usual number of shifts for 24 hours, the statement of relative operating expense is as follows:

WATER-TUBE PLANT.

With Mechanical Stokers and Coal Conveyers.

6 firemen, at $60 per month	$360
2 boiler men, at $65 per month	130
2 boiler men, at $55 per month	110
4 coal men, at $55 per month	220
1 ash man, at $55 per month	55
Total	$875
Total cost for one year	$10,500

RETURN-TUBULAR PLANT.

Hand Fired and No Conveyers.

24 firemen, at $60 per month	$1,440
1 boiler man, at $65 per month	65
2 boiler men, at $55 per month	110
15 coal men, at $55 per month	825
6 ash men, at $55 per month	330
Total	$2,770
Total cost for one year	$33,240
Less cost of water-tube plant	10,500
Difference for one year	$22,740
Total difference for 20 years	$454,800

I believe this elucidates my former article and covers the real point under discussion, viz., mechanical versus manual operation of an 8000-horse-power plant; for again quoting from the original article (page 82 of the February number): "The only place where further investment might save anything would be in labor cost of operation, as by the use of mechanical coal conveyers and stokers, and Mr. Diman would like to be shown how his plan can be bettered in this respect." By the way, I forgot to figure the coal horses in on the expense account—but, there, I will rest my case as it is.

In conclusion, several other arguments might be started in addition to the labor question. For instance, can coal be burned as efficiently by hand firing as by a stoker? Or, is 5.4 per cent. carbon dioxide in flue gases good economy? Or, does a low uptake temperature necessarily denote high efficiency?

In regard to the flue-gas record, I submit the inclosed chart taken from "Smoke Prevention and Fuel Economy," by Messrs. Booth and Kershaw. Not knowing any more than the average engineer about flue-gas analyses, and perhaps not much less, nevertheless this chart has proved very interesting to me and may to others. Suppose, for example, the temperature of gases is taken as 250 degrees and the CO_2 as 6 per cent. Compare this with the chart and the percentage of wasted heat is seen to be rather small. Now take the uptake temperature at 460 degrees and the per cent. of CO_2 at 6, and compare this with the chart. Deduct the per cent. of saving by the economizer from this, and the percentage of wasted gases has grown perceptibly. Where does it go? Does it indicate excessive air? I respectfully refer interested readers to the article on this subject by Professor Gill in November, 1905, POWER. Perhaps a great many passed the article up at the time, as being too deep for them. However, a year makes a big difference in the mental status of an engineer and it may prove very interesting at present, especially after reading the recent editorial on the subject, and also the article on pipettes, by Harry Spurrier, in the April number.

PERCENTAGE OF FUEL LOST* BY HEAT LOSSES IN EXIT GASES AT VARIOUS TEMPERATURES.

Percentage of CO_2 in Exit Gases.	4	5	6	7	8	9	10	11	12	13	14	15
Temp. ° Fah.												
100	8.1	6.5	5.4	4.7	4.1	3.7	3.3	3.0	2.8	2.6	2.4	2.3
200	16.2	13.1	10.9	9.4	8.3	7.4	6.7	6.1	5.7	5.3	4.9	4.6
300	24.3	19.6	16.4	14.2	12.5	11.2	10.1	9.2	8.5	7.9	7.4	6.9
400	32.4	26.2	21.8	18.9	16.4	14.9	13.4	12.3	11.4	10.6	9.8	9.2
500	40.5	32.7	27.3	23.6	20.8	18.6	16.8	15.4	14.2	13.2	12.3	11.6
600	48.6	39.3	32.8	28.3	24.9	22.3	20.2	18.5	17.1	15.9	14.8	13.9
700	56.7	45.8	38.2	33.1	29.1	26.0	23.5	21.6	19.9	18.5	17.2	16.2
800	64.8	52.4	43.7	37.8	33.2	29.7	26.9	24.7	22.8	21.2	19.7	18.5

*Losses calculated for coal containing 13,500 B.t.u.

Ed. H. Lane.

Kansas City, Mo.

Engineers and Manufacturers Ought to Exchange Ideas

In reading over the communications in the "Practical Letters" department of POWER, it is apparent that the operating engineer, with his troubles and their solution, finds first place. Operating engineers admittedly constitute one fundamentally important class of "practical men." There is another class, however, who are daily bending their energies and ingenuities to produce satisfactory material for these men to work with in the power plants. The interests of both are common in a great many ways and should be so regarded.

This thought was suggested by Mr. Brocklebank's letter in the May number, in which is set forth a difficulty he has successfully battled with in regard to the lubrication of certain large engines. The writer, being somewhat in touch with the manufacture of lubricating apparatus, fully appreciates the circumstances and the correctness of Mr. Brocklebank's theory. These difficulties are not always foreseen by the designer, whose energies are bent toward the production of an article that will be practicable to manufacture and at the same time prove satisfactory.

In seeking a solution for this problem, and many others along these lines, if engineers would carefully report the nature of their difficulties to the manufacturer, two desirable ends would be very often attained: The manufacturer would be shown wherein his apparatus may be at fault, and be led to make the necessary changes to overcome these objections; the engineer would be helped over the hill of difficulty.

Finally, I wish to point out the peculiar backwardness of power-plant customers to report objectionable features to and coöperate with manufacturers. Engineering progress in general would certainly be strengthened by such coöperation.

Kay.

Milwaukee, Wis.

A Plea for Instructive Power-plant Catalogs for Sawmill Men

If there is any one place more than another where enlightenment on the subjects pertaining to power production and application gives promise of fruitful results both to the users and furnishers of power, that place is among the small sawmills in the woods. I might include some of the larger ones, too, and mention also the farmer, with his plantation engine, who has need for some enlightenment. The farmer is another problem, however, and is not as ripe for fruitful work in the educational line as the sawmill man.

From a careful survey of the sawmill field one can find a peculiar condition of affairs in regard to power machinery and equipment. The modern Southern mill-owners, when they buy machinery, generally buy the best and most up-to-date that can be had, or at least that which they are led to believe is the best. At times they don't take as much pains or give as much thought to the power part of the equipment as to the machinery in the mills, because fuel is no object. They look for strength and durability in their power equipment, that is, the more enterprising ones do, while many others, especially those operating smaller mills, look too much to the first cost. In ignoring fuel as a primary object the man who is looking for up-to-date appliances but does not give specific attention to power economy because fuel is no object is frequently led to ignore or overlook many appliances and details of equipment which are naturally a part of power plants where fuel is a great object, and which would contribute greatly to the durability and reduction of maintenance cost in his power plant. The errors that the man may fall into who is looking at the dollars of the first cost more than anything else are too numerous and well known to require elaboration here.

The point I am trying to emphasize is the advisability of supplying to users and prospective users of power in the woods information on the subject of right ideas of power-plant equipment. Sawmill men as a rule are willing, when it is made clear to them that any course offers advantages, to follow that course. We have had examples of this without number in the machinery line. Take saws for example; when he finds by actual demonstration in his own mills that one make of saws will run longer, stand up better, and give better service generally than a cheaper make he does not hesitate a minute to buy the more expensive saws. The same thing is true of other machinery about the mill; instances are known where mill men have made it a point to purchase the highest priced planers for a given class of work after getting quotations from numerous machinery houses, because they found from experience that the best is the cheapest in the end, and they take it for granted that the best naturally costs the most money.

Unfortunately the sawmill man is unable, for obvious reasons, to get a comparative demonstration in his own mill of the different qualities of different power-plant equipments, and because of this fact he is sometimes lost in his search for positive and convincing information on the subject of power plants. Besides, he always has an inclination to dismiss this subject on the ground that fuel is no object. Now, the fact of the matter is that while fuel primarily is no great object in the sawmill, power-plant equipment should receive a great deal more attention than it gets, because there is a lot more to it besides the factor of fuel. Right here is where the intelligently prepared catalog scores. Many people in the sawmill business today don't understand or appreciate the possibilities of a power plant. They need some enlightenment. They probably would not take it kindly if a man were to go to them and tell them of their ignorance in this line, but that is not necessary. They can be educated without antagonizing them or hurting their feelings.

A point that present conditions in the industry make more worthy of notice now than heretofore is portability combined with power. What is needed is the most power possible and in the best shape practicable for easy and inexpensive moving from place to place. This is needed especially among the small mills, because timber is scattered, necessitating frequent moving and setting for small mills. What this calls for is, of course, the use of higher boiler pressures than are commonly used in the woods and the sawmill man needs information on the subject of the advantages that may be derived from higher pressure, and how to go about getting it. It goes without saying that boilers and engines built for higher pressure will cost a little more money primarily than those built to stand low pressures, but it should not be a very difficult task to find plenty of convincing logic to lay before the prospective user to show that this additional expense in primary equipment is a good investment. The same logic that applies to the boilers and the engines applies equally well to the fittings, flanges, valves and everything else.

Every manufacturer of power equipment thoroughly understands the points made here, and can call to mind a lot of others that might be made, but most of them will probably ask, "What's the use?" What's the use to talk quality to men who don't appreciate it and are not willing to pay for it? The answer is, those are the very men to talk it to. The men who appreciate quality will come looking for it, and the real place to do educational work is among those who have not yet learned to appreciate it. Of course, there has been lots of missionary work done along this line, and the discouraging feature is that it doesn't seem to bear the fruit it should. Nevertheless, what we really need is more of it, and probably the best place to do it is in the catalogs. That's where the saw men have done a world of good work by furnishing a lot of information not only about saws but about how to use them to get the best results. The same thing should apply in catalogs of boilers and engines, and continued efforts should bring fruit, provided the efforts are properly made.

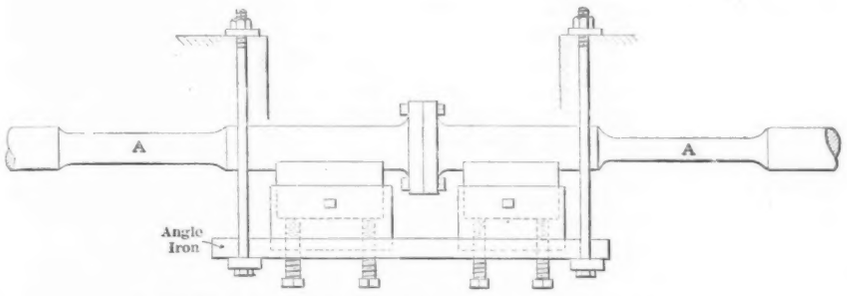
It is possible that in this work the makers of catalogs have got something to learn, too. Possibly some of them will have to get down off a plane that is too high and too distant from the work-a-day plane of the average sawmill man. Highly technical and scientific information is a good thing and absolutely necessary to proper advancement, but it does not fit the understanding of the man in the woods. It is at times quite a difficult task to convey technical information in plain every-day language, but it can be done to a sufficient extent at least to answer the purpose indicated above. What is really more needed, however, is the giving of more specific information about the comparative merits of different power equipment. It is not interesting to the average sawmill man in the woods to read claims as to the saving of a certain percentage of fuel; he does not like to figure percentages and has fuel to throw at the dogs, but if you can show him how to save dollars and cents then you've got him coming. It doesn't pay to make any claim that can't be substantiated. Figure out what you've got to offer as compared with what he may have already, and then don't hesitate to tell him about it and show him why and how. In catalog work for sawmills, the fuel question is not a factor at all; there are plenty of other factors that can be found and presented simply and forcefully in catalog pages.

"Why catalogs?" Because the people in the woods will probably read catalogs more carefully than will any other people—they have more time for reading and less other material to read. This doesn't mean that manufacturers should not use any other means, but the catalog does suggest itself as being one of the best vehicles for pushing educational work in the field under consideration. The time is ripe, the enlightenment is needed, and if properly given will bring good results. Of course, my remarks must not be construed to mean that all manufacturers are indifferent about sending catalogs to the class referred to; neither would I be understood as implying that the majority, even, of that class are ignorant.

Louisville, Ky. J. C. TAYLOR.

Shaft Badly Worn by Wood Bearings

If I were to write a set of Thou Shalt Nots for designers of water-wheels, the first would be: Thou shalt not use inside wood bearings.



SHOWING SHAFT WORN BY BEARINGS, AND THE REMEDY

In this locality, where the water is so thick at times that it rolls instead of flows, wood bearings are responsible for the condition of the shaft shown at *A A* in the accompanying sketch. It requires about three years to do this. If the wear were equal around the shaft, one would not mind so much, for it would even then be possible to make the turbine run without shaking the whole building. But, as the sketch indicates, the wear on one side is about 1½ inches and on the opposite side only ½ inch.

The illustration also shows how by means of two pieces of angle iron, two clamps, two boxes of ½-inch sheet steel, and with two cast-iron plates to bridge across the angle irons and support the boxes, we changed the location of the bearings on the shaft. As a result the wheels now run almost as smoothly and quietly as when new, and it seems that life will be worth living for the next year, anyway. At the end of that time we hope to have a new shaft.

Mesa, Arizona. FRANK W. CERNY.

How Would You Correct the Crank-end Diagram?

The inclosed diagrams are submitted for the benefit of the boys who like to guess. They came from a 14x36 Corliss engine, running at 92 revolutions per minute, and, strange to relate, it did not "raise Cain" while it was doing the trick.

Greenwood, S. C. A. P. ALDRICH.

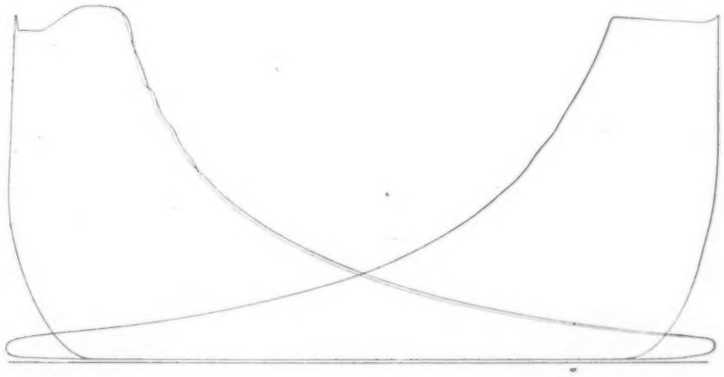
What Causes the Dynamo to Spark?

The brushes of a 45-kilowatt bipolar dynamo spark at all loads. The sparking is not due to grounds. The commutator has been turned down a good many times. What is the cause of the sparking, and how can it be stopped?

Brooklyn, N. Y. H. B. BRAND.

What Is the Matter with the Steam Line?

I submit herewith a diagram from our 16x42 Twin City Corliss engine, running at 81 revolutions per minute. Can any of your readers tell me what is the cause of the peculiar shape of the steam line? How can I adjust the valves to get better economy? I notice a slight jarring when the engine is passing centers. There is no play in the boxes.



WHAT IS THE MATTER WITH THE STEAM LINE?

Caldwell, Kan. E. J.

Inadequacy of Windmills as Prime Movers

Careful prony-brake tests show that in a 25-mile wind, which is better than the average, a wheel 8 feet in diameter gave in useful work, pumping water, 0.12 horse-power, while a wheel 12 feet in diameter developed 0.64 horse-power, and these figures are the best for the sizes shown out of over 50 tests of almost as many makes.

It is not likely that any locality will average more than 5 days, or 120 hours, a month in which the wind exceeds 20 miles per hour, unless it be on the Pacific coast. To arrive at an average, then, calculations should be based on what the mill will do on a 20-mile wind. Following are the results in detail from the most powerful mill tested, which had a wheel 30 feet in diameter; lift to tank, 135 feet:

Velocity of Wind Miles.	Gallons Pumped.	Horse-power.
8	6.7	0.23
12	16.9	0.58
16	22.5	0.77
20	27.0	0.92
25	31.5	1.07

The cost of repairs to the mill and pump is reported as being between $50 and $60 per annum.

To take another view of it, a calculation of service of a 16-foot windmill averaged 488 horse-power-hours per month over a period of one year. By the time the water elevated by these 488 horse-power-hours had gone its way through the proposed hydroelectric generator there would probably not be more than 300 horse-power-hours left for the average month.

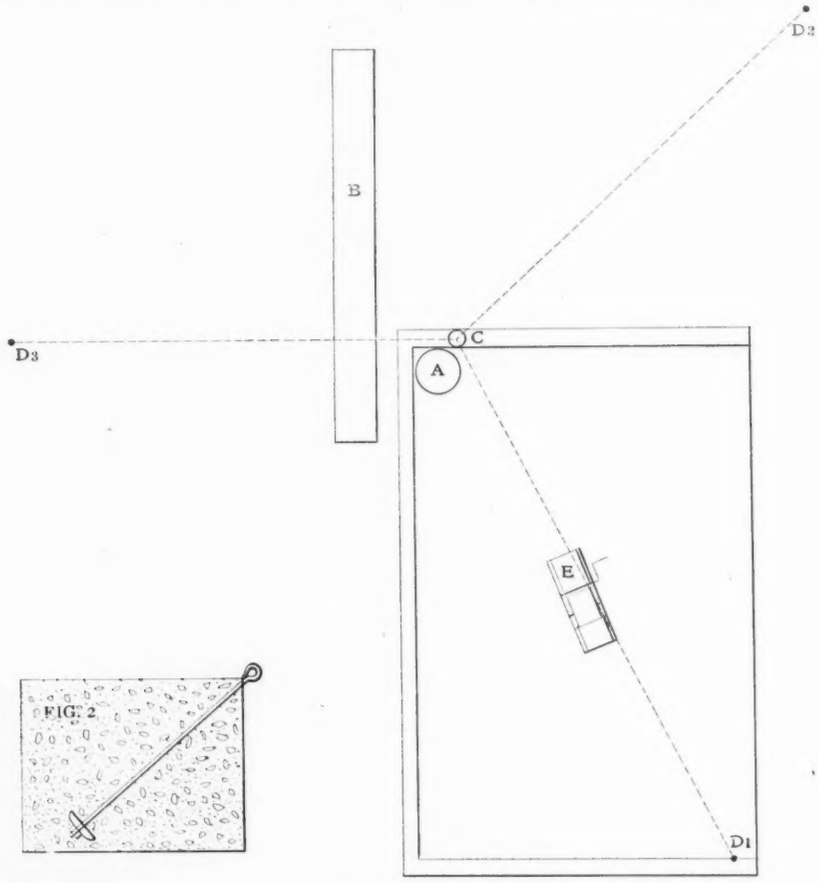
Greenville, Penn. ALEX M. ORR.

DIAGRAMS FROM A 14X36 CORLISS ENGINE, RUNNING AT 92 REVOLUTIONS PER MINUTE

How Dave Erected the Stack

The stack was a sheet-iron one 48 inches in diameter and 80 feet long. It was shipped in three sections to the plant and riveted on the ground. The contract to erect both stack and boilers was placed with the Blanktown Iron Works and they in turn sent Dave out on the stack job.

The building was of brick, two stories high, 120x70 feet in plan and the stack was to go through the roof in one corner. Fig. 1 will give an idea of the ground plan with the hole for the stack shown by the circle marked *A;* the original position of the stack at *B;* the location of a gin pole to hoist from at *C,* braced with three guy ropes at *D1, D2* and *D3;* and the winch at *E*. The hoisting rope led from the winch to a block bolted to the parapet wall at the base of the pole *C,* and thence to the triple blocks at the top of the pole.



HOW DAVE ERECTED THE STACK

The guy wires which were to hold the stack in position when erected were made fast to the ring riveted to the stack for that purpose and left coiled close at hand so they could be handled easily when wanted. A sling was passed around the stack close to the center and the hoisting line made fast. Then at a signal from Dave the men at the winch began work and as the stack was lifted, the bottom end was held down by some of the men making it approach a vertical position. When nearly to the top of the roof, the guy *D1* broke and the whole thing came down in a heap. Fortunately no one was injured and beyond some of the riveting, the stack was not much damaged. Procuring a new guy rope to replace the broken one, the same rig was replaced and tried again. This time he was successful and as the bottom of the stack cleared the parapet wall, it was swung around over the hole and lowered to its gray-iron seat on the brick sub-base.

The guy wires were then made fast to the dead-men prepared for them. Where these dead-men came in open ground, they were prepared by digging a hole about 4x4 feet square and 5 feet deep. An eye-bolt made of one-inch iron was placed in this hole in the proper direction and at the proper angle for the guy wire, and the hole was then rammed full of concrete made in the proportion of one part cement, four parts sand and eight parts broken stone. Fig. 2 will give an idea of this dead-man as it would look in section. Tightening the guys and removing the rig left the stack ready for use.

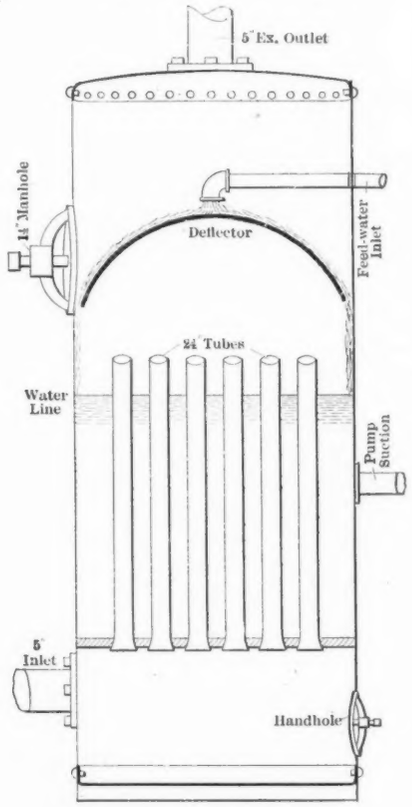
Several years after this, it was decided to add two 20-foot sections to the top of this stack and Dave was once more engaged to do the job. This time he staged the entire stack from the roof, using 4x4-inch material for the corners and bracing with lighter lumber. The pieces were hoisted separately, placed in position and riveted, after which the stage was removed.

At another time the round brick chimney of a large factory developed cracks near the top and it was decided to place some iron bands around the defective places. This stack was 165 feet high, and about 7 feet inside diameter. The work had to be done without stoppage, so the stack was staged from the outside and six flat iron bands placed around the cracked parts. These bands were drawn up with the regular malleable tank-band buckle, using two 7/8-inch bolts for tightening.

East Greenwich, R. I. L. L. ARNOLD.

How Can He Improve His Heater?

The sketch submitted herewith is intended to represent a vertical open heater,



MR. STEINER'S OPEN HEATER

24x60 inches, and I wish some of your readers would tell me how to arrange it so it will separate oil from the steam.

As the sketch shows, the tubes, which are open at the top, do not fill the shell horizontally by a few inches, so that the feed-water from the deflector overhead does not enter the tubes, but runs down the sides of the shell. The water level is always maintained to within a short distance of the tops of the tubes. The space between and around the tubes is packed with hay or excelsior to catch sediment, etc. There is no tube sheet at the top.

Bern, Kan. D. A. STEINER.

Trouble with a Water System

Recently the company I am with moved into a building equipped with a water system, for general washing purposes, consisting of two tanks on the roof supplied from a 5¼x3½x5 Worthington duplex pump in the basement. The tanks are about 150 feet apart, connected by a 2-inch equalizing pipe from which are dropped three supply pipes down through the building to the basement. From these supply pipes laterals are run on each of six floors to supply the various washstands, toilets, etc. The general arrangement is shown in Fig. 1, and I presume this worked all right for the small consumption of water. From tank No. 1 a pressure pipe led to a pump governor in the basement.

Our business requires large quantities of water, and we soon found that the installed system would not take care of us, because at times we would pull so hard from one tank that it would be empty while the other would overflow, or else the other would be empty while the first would be full and the pump would be shut down by the pump governor. The 2-inch equalizing pipe was unable to keep equal levels in both tanks, consequently the tanks were overflowing and freezing up drain pipes and gutters, or else people were kicking for water. All this would occur at the same time from different tanks and kept us continually in trouble until I was able to get a high- and low-water electric alarm installed on each tank, with an annunciator in the pump-room, which would register immediately which tank was in trouble and what the trouble was, so that either the valves to the tanks could be opened or closed, or the pump shut down if both tanks were full.

As soon as our men can get time I expect to get rid of all of this trouble by installing a pressure system, such as is shown in Fig. 2, which appears to me to be likely to solve our problem. It does away with all open tanks on the roof.

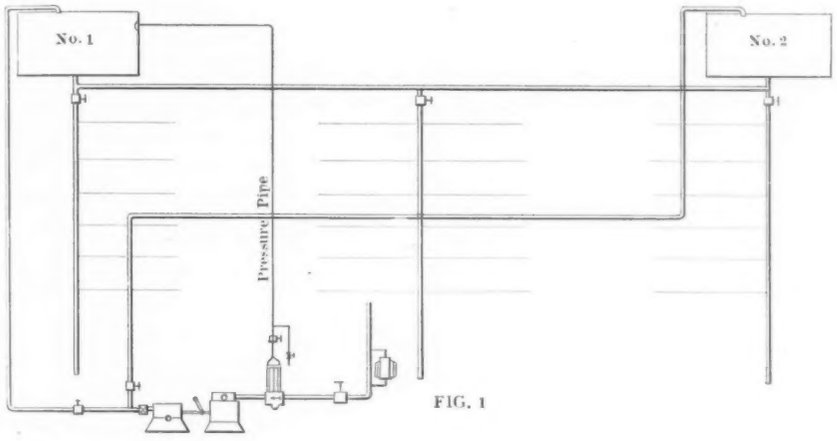


FIG. 1

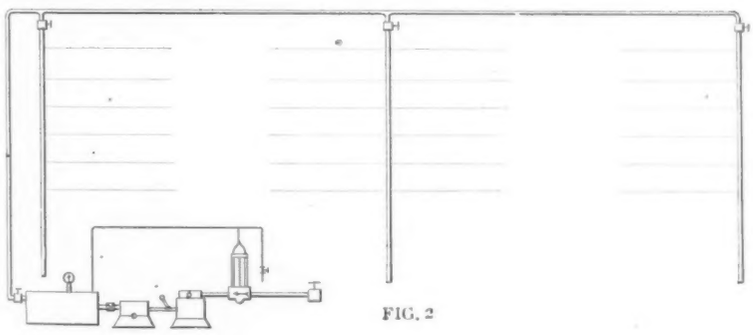


FIG. 2

PRESENT ARRANGEMENT AND PROPOSED WATER SYSTEM CONTRASTED

I hope some of the hints conveyed in this letter may be of use to others, as they would have been to me some time ago, and I would also be glad to have any suggestions on the proposed system, so that it will be as nearly perfect as possible.

WM. S. DOUGHTEN.

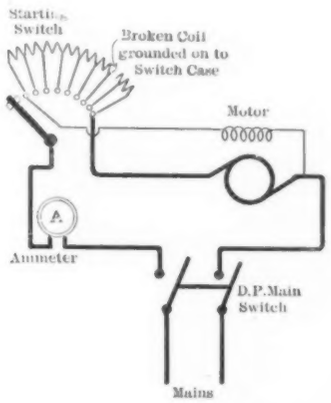
Philadelphia, Penn.

Making a Motor Go

Some time ago I was sent to locate the trouble in an electric motor which had "jibbed." The motor was coupled up to drive mechanical-stoker gear and was supplied at 500 volts from the outer wires of a three-wire system. The machine was equipped with a double-pole main switch and a starting switch, an ammeter being in the main circuit, as illustrated in the accompanying diagram. The neutral conductor of the system was permanently grounded.

An examination of the apparatus showed that it was mechanically perfect. The motor was uncoupled from the gear and an attempt made to start up; but, although the starting switch was moved over until the ammeter indicated one and a half times full-load current and the field was found to be on, the motor refused to budge. The starting switch was then put into the off position and on operating the main switch there was a rather bad flash. The main switch was closed again and on testing the field magnets by holding a steel key close to them, they were shown to be excited. All connections were examined and the position was altered, but with no better result.

After a hunt we found that the trouble was due to one of the starting coils being burned through and fallen on to the cast-iron case containing the rheostat, forming a ground. The accompanying diagram shows what was happening. When the main switch was put in, the current went through the field winding, then through the starting resistance to earth, putting the field winding across 250 volts; this accounted for the flash on opening the main switch. When the starting switch was operated it simply fed the current through the ammeter and part of the starting resistance to ground. On replacing the burned-out resistance coil the motor started up satisfactorily and ran normally.



SHOWING THE TROUBLE WITH "ERG'S" MOTOR

Brompton, Eng. ERG.

Curing Water Hammer in Duplex Pumps

Recently I had occasion to correct several faults in the method of operating a pair of pumps. They are compound duplex pumps with cylinders 8x12x8¼x12, and inside packed pistons, supplying water for a town of 2000 inhabitants.

The pumps work on tank service the greater part of the day and on direct pressure during the sprinkling hours, from 6 to 8 a.m., and 5 to 7 p.m., but they used to refuse to run smoothly and customers were all the time complaining about the excessive noise in the pipes. Occasionally it is necessary to run both pumps at the same time, when the demand is great, and as each is controlled by its own governor and the pumps cannot be isolated by cutting the discharge main into sections, it was by no means an easy matter to keep each working up to its share of duty.

The first corrective applied was to repack all steam-end rods properly; next, the valves were set and lost motion adjusted, but these changes improved conditions very little. Upon inspection of the water cylinders there were found evidences of considerable wear. A good dose of melted tallow bestowed on the cylinder walls worked wonders with one pump (the first one tried), whereupon the piston packing was removed and placed in an iron kettle containing tallow, in which it was boiled about thirty minutes. The other pump was given the same medicine. After re-packing the pistons the pumps worked beautifully, and have ever since.

These pumps now pump more water with the same amount of steam and will run faster than before, with no water hammer at all. The water-end rods are packed with square flax packing cut with square joints and also boiled in tallow. Before this treatment, graphite and various oils had been tried upon the water cylinders, but without effective results, although graphite helped the steam cylinders greatly. The water is very hard.

The manufacturers of the pumps took particular pains to jacket the steam cylinders thoroughly, while the steam chests, which have two-thirds as much outside surface as the cylinders, are not protected at all. I wonder if the builders reason like the man who refused to buy pipe covering, because, as he said, "all the work is being done in the cylinder and not in the pipe."

If an engineer is painstaking and somewhat ingenious, he can cover the exposed surfaces very nicely by using asbestos millboard and filling the corners, crevices and odd places with a paste made from asbestos, wool, cement and water. The job can be smoothed up nicely and a coat of paint will greatly improve the appearance. If he desires, he can strengthen it by using bands cut from sheet-brass or Russia iron. This millboard can be purchased from supply dealers and comes in various dimensions. It is always advisable to fit the steam-chest covers with removable coverings, to facilitate inspection of the valves, and cylinder heads may be treated likewise.

Zeeland, Mich. J. EDW. KAMPS.

To Prevent Air Leaks in Turbine Gate Valves—Two Cures for Dishing of Valves

After a general machine-shop practice extending over a period of something like ten years and ranging from chipping castings to tool-making, I am back in the fold. I find that a great advance has been made all along the line, which I have not followed up, as I expected to stick to the machinist's trade. However, I believe I am better off for my experience.

One who has not tried it cannot realize the difference between working at the bench and assuming the care of an electric-light plant which includes one 250-kilowatt belt-driven generator and two 400-kilowatt turbo-generators.

When I took charge of this plant, the operators were having trouble with the vacuum, and one of the improvements I introduced is shown in Fig. 1 herewith. The gate valve for turbine No. 1 leaked between the disk and seat, allowing air to pass while No. 2 was in operation. As now arranged, the ⅜-inch water pipe is so located that water will be carried between the disks in the gate valve. The ¼-inch drain is located in the turbine end of each gate, so that if any water should leak by, it can be readily drained. The space between the disks is bound to fill with water, as we always maintain at least 20 pounds pressure.

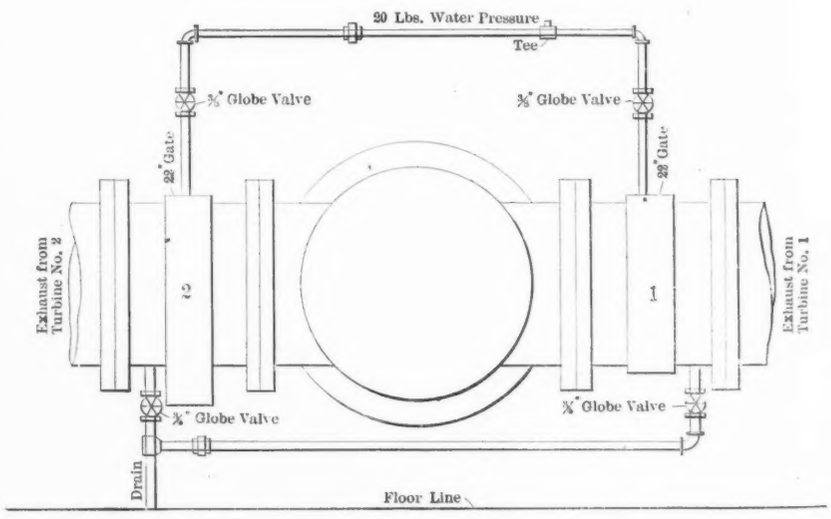


FIG. 1. DEVICE TO PREVENT AIR LEAKS IN TURBINE GATE VALVES

Another thing I did was to put stiff plates (Fig. 2) on the air valves and brass bushings in the holes, to prevent dishing of the valves, a condition which induced a rubbing of the lower side of the valve on the seat, causing the valve to rough up and gum, with results easily imagined. At the time I did this I came to the conclusion that if I were doing it over again I should make a flanged disk to fit over

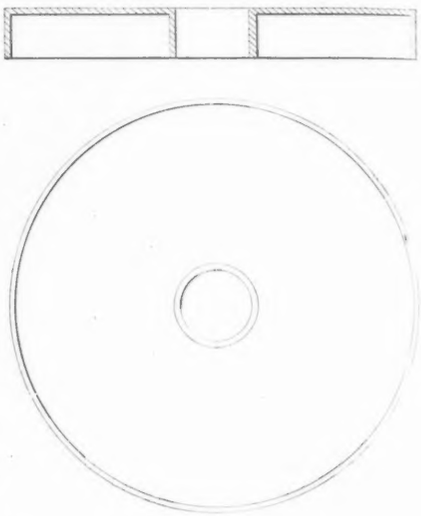


FIG. 2. AIR-VALVE PLATE TO PREVENT DISHING OF VALVES

the edge of the valves; but, as it was, I used a valve five-eighths of an inch thick, instead of one inch, thereby saving considerable cost, and the valve, being protected from the action of the spring, could be reversed any time, its efficiency being considerably increased thereby. Later on, however, at the suggestion of an old "war horse" in the business, I made a flange to fit down over the outside of the valve to prevent it from spreading. I found that brass castings machined all over inside were preferable.

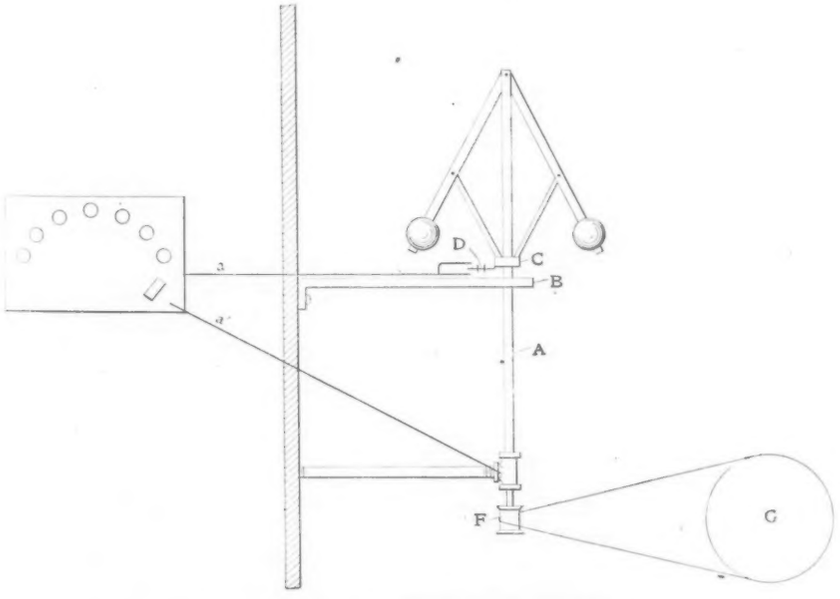
Anderson, Ind. NEW MAN.

A Safety-stop Governor

I should like to call the attention of POWER readers to a "safety-stop" governor devised by F. W. Somerville, engineer for the Dow Chemical Company, Mount Pleasant, Mich., with which he regulates within the limit of safety the speed of an electrically driven pumping rig.

A is a ¾-inch steel rod turned to ⅜ of an inch for a distance of 6 inches from the lower end; *B* is a short piece of 2x4-inch steel with a 1-inch hole in which the stem is babbitted; *C* is a ¾-inch pipe coupling babbitted to fit the stem, to which a pin *D* is attached. The pin *D* works between two 2x4-inch pins driven in as guides to the pin on the union; *E* is a ¾-inch T babbitted to the ⅜-inch end of the stem, on which the shoulder of the stem rests; *a* is No. 16 gage, covered wire, one end of which is attached to a magnet on the starting box, while the other end is bifurcated, one fork being placed near the top of the guide pins and the other at the bottom; *a'* is a No. 16 gage wire connecting *E* and the other terminal of the magnet; *F* is a wooden spool for the belt which runs from the shaft *G*.

The cut shows the pin *D* in the working position. It is evident that if the speed increases or decreases sufficiently to raise or lower the pin, to engage either wire, the current passes through the governor, cutting out the magnet and allowing the starting box to fly out. This little governor works to perfection, and by its use Mr. Somerville governs the speed of his pump to a stroke.



MR. SOMERVILLE'S SAFETY-STOP GOVERNOR

This device comes in very handy, as may readily be conceived by studying the sketch.

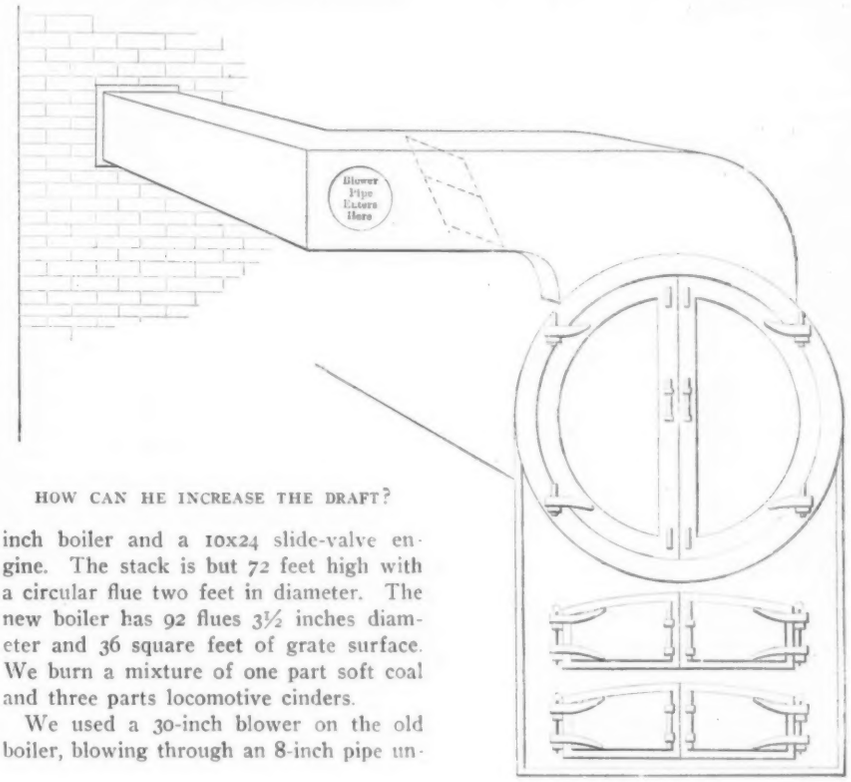
Mt. Pleasant, Mich. I. M. GOODWIN.

How Can He Increase the Draft?

We have a 72-inch boiler, 18 feet long and are troubled with insufficient draft. The chimney formerly did duty for a 54-inch boiler and a 10x24 slide-valve engine. The stack is but 72 feet high with a circular flue two feet in diameter. The new boiler has 92 flues 3½ inches diameter and 36 square feet of grate surface. We burn a mixture of one part soft coal and three parts locomotive cinders.

We used a 30-inch blower on the old boiler, blowing through an 8-inch pipe under the ash-pit. I found I could do far better without it on the new boiler and fired with the ash-pit doors open, using natural draft, but in winter it is hard work. I persuaded the firm to connect the blower to the uptake. I wanted the pipe to extend through the uptake at the opening opposite the chimney to the center of the chimney and then turn up with an elbow, but the tinsmith said: "No, just take the pipe to the uptake and the air the blower delivers simply has to go up the chimney."

His plans were executed but I find it retards the draft. It is a 30-inch blower and runs at 2500 revolutions per minute. Can I not utilize it somehow to create a forced or induced draft? The accompanying sketch shows the position of the boiler and the uptake.



HOW CAN HE INCREASE THE DRAFT?

THOS. W. BURDEKIN.

South Framingham, Mass.

"Troubles with Crude-oil Fuel"

Frank W. Cerny, on page 181 of March POWER, mentions trouble with flues while burning oil under boilers. I presume he is running a return-flue boiler, and if so I see no reason why oil should be any harder than solid fuel, provided the burner is properly set and the boiler not forced too much. I am burning oil in a vertical boiler, and find some trouble to protect the flue ends. There is a fire-brick arch in the boiler, but sometimes it comes down, and if the burner be run even half a day without the arch there is trouble; mainly it starts the rivets leaking and sometimes the flues. The boiler is of the submerged-flue type, and the top ends give no trouble.

I would also like to ask some of the other engineers what they think about putting a 2-inch pop safety-valve at the end of a 12-foot horizontal pipe with an ell at the boiler. I saw the arrangement at a sawmill two weeks ago. Is it safe?

Auburn, Cal. C. M. WILLIS.

"The N. A. S. E. and Engineers' Wages"

In the March number, page 182, R. Cederblom proposes a plan for getting engineers' wages raised. Theoretically it ought to accomplish its object, but practically I fear it would be a failure. He holds the opinion that the average employer does not appreciate the work of the engineer, but in this I cannot agree with him. The employer puts the engineer in charge of expensive and, at times, intricate machinery, as well as dangerous power generators, and expects him to be able to undertake the responsibility of the maintenance and efficiency of the one and the safe performance of the other. Therefore the employer *does* understand that he must have a man who ranks above the laborer in intelligence and character.

Why, then, does the engineer not get more pay? Because, generally speaking, his employer knows that he can obtain just as good a man for the same money, and sometimes for less. I know an engineer who works 88 hours per week for $20, and this is not an exceptional case.

Here are men shouldering the responsibility of numerous lives and millions of property, who must be ever watchful while on duty; and, when others are enjoying leisure, engineers have to study in order to keep up with progress and improve the working of the plants; for which they receive laborers' wages. It is true that the pay of engineers has been increased, but not in proportion to the duty required, nor to the pay received in other occupations.

Although agreeing with the principles of the N. A. S. E., I fail to see wherein they were ever instrumental in increasing wages. Mr. Cederblom's plan of issuing certificates to competent members would eventually leave us where we are at present, because we should probably all hold such certificates, and so all would have equal claims for consideration. As in every other occupation, the supply of engineers exceeds the demand, but unlike others we have no fixed minimum wage scale. We cannot be classed as mechanics, nor as professional men; yet every day we are going farther away from the mechanical and approaching the professional; the pencil and scientific instruments are in our hands oftener than the hammer and wrench—and here is where the union gets out of step. Closing down a plant on strike orders could be done only in comparatively few cases, as the engineer is more nearly in touch with the employer than other employees, and is too much interested in the machines under his charge to leave them willingly.

As to overtime work, some employers pay for it, while others do not, on the principle that the engineer is paid for holidays; but they do not consider the time given on Sundays and that spent in making necessary repairs and adjustments, washing boilers, etc., when shut down at night, which would very much overbalance the few holidays each year.

Perhaps, if it could be arranged between all the societies to send members to a convention to agree on a mixed delegation to wait upon employers in a friendly spirit and lay the facts before them, something might be accomplished in the desired direction.

Chicago, Ill. WILLIAM CHADDICK.

Steam Heating Under Difficulties

A friend of mine recently took charge of a plant which had deteriorated considerably, and his experience will, I believe, interest POWER readers. This plant was formerly heated by exhaust steam, it would seem, as my friend found a back-pressure valve which had evidently been used in connection with such a plan. The lever of the valve had been lengthened to two feet six inches and an old die of about 75 pounds weight had hung on it. Apparently this arrangement caused too much back pressure on the engine and had in consequence been discarded. Then it seems an obsolete type of steam trap had been placed on the top of one of the side-walls of the boiler, the idea being to use live steam and return the water of condensation back to the boiler. This device was in use when my friend took charge of the plant.

The old trap was supposed to work automatically by means of a roller and tilting arrangement, but owing to the parts being badly worn the device only worked by spells. To remedy the trouble a long wooden lever had been attached to the trap, the lower end of the lever extending down by the side of the boiler, so that it could be used by the engineer to pump the water out of the system. While this helped matters a good deal, it also involved much extra work for the engineer, as well as considerable kicking from the office if he accidentally forgot the pumping act.

After considerable persuasion my friend induced the management to purchase a duplex pump and receiver, which were installed in the engine-room, where they were accessible for repairs and cleaning. The old trap was consigned to the scrap heap. Although the new apparatus worked considerably better than the old, still the anticipated results were not realized.

One day, having a little spare time, my friend thought he would inspect the piping and found that the main line was 1¼ inches diameter only. While that was possibly large enough for the amount of steam that was used at the time it was installed, owing to various extensions to the plant it had become altogether too small. It also had another bad feature: when this system was put in, the fitters absolutely disregarded the effect of pockets in the pipe, and when a beam or another pipe was encountered, they simply used an ell, dropped the pipe down about a foot and then came up on the other side. There were eight or ten of these magnificent specimens of steam fitting.

To inspect the return line it was necessary to go under the floor, where there was no cellar; but a space had been left from one to four feet in hight. After prowling around a while my friend found the drip-pipes, and, while the construction of the steam line had appeared bad enough, it was a scientific marvel compared with the return-pipe layout. Here each radiator had a separate pipe, which extended the entire length of the building. These varied in rise from ½ to 1¼ inches. They had become loosened from their supports and sagged down in the middle about six inches, thus forming more pockets. All of the original piping was done by a local steam-fitting firm, whose workmen had been allowed to do as they pleased, as long as they made a connection of some kind. This privilege they seemed to have taken advantage of by using up stock. One pipe in particular was extended 70 feet in one direction, then carried across nine feet and brought back 20 feet toward where it commenced. As there was very little room under the floor, and as it was also a very dark and dirty place, detection of this loose way of doing work seemed hardly likely.

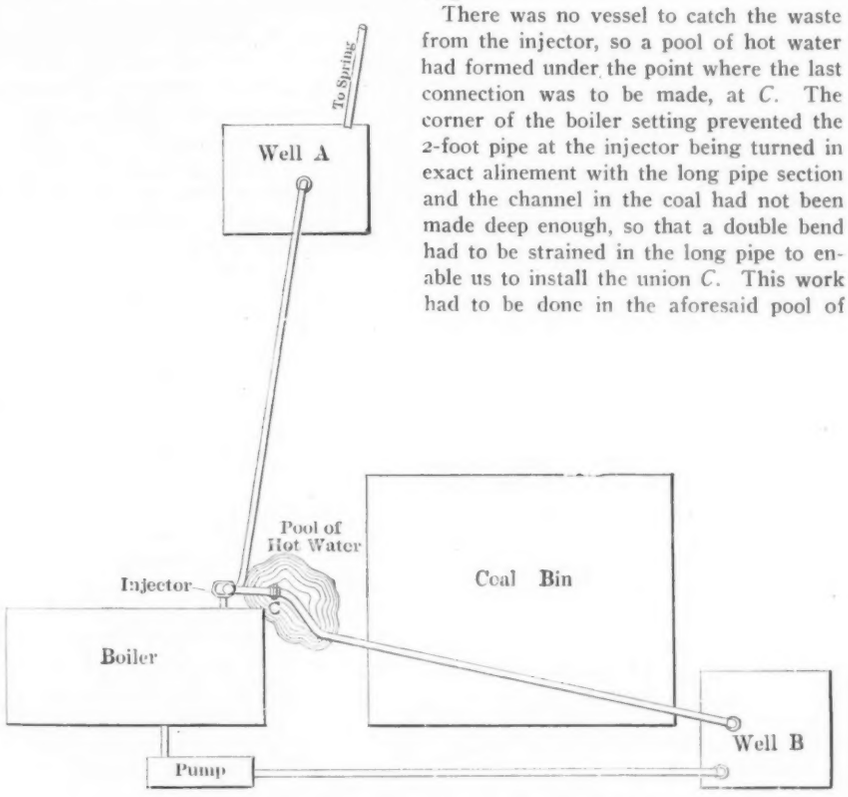
After the management had become aware of the conditions, preparations were made to remove the various lines of return pipe, as well as the steam line, and replace them with something better. A 2½-inch main return pipe was carried the entire length of the factory and branch connections were made with each radiator. The main return was given a 14-inch pitch toward the receiver. A new two-inch steam main was installed in an absolutely straight line the entire length of the factory, the connections being taken from the top of the pipe to the different radiators, thus insuring a supply of dry steam for each.

A drip-pipe was connected on the end of the steam line to the return pipe, thus taking care of the condensation in the main line. A reducing valve was also installed in the main line in the engine-room and the pressure was reduced from 90 pounds to 10 pounds. As the receiver was about six feet higher than the lowest point in the return pipe, 10 pounds was found to be insufficient to raise the return water into the receiver, one pound to each two feet of rise being necessary; so a pressure of 15 pounds was maintained at the reducing valve at all times with excellent results, both as regards heating and a notable reduction of expense.

Bridgeport, Conn. C. H. T.

A Ticklish Job in the Night

The sketch herewith illustrates a peculiarly vexatious condition which confronted me when I was night engineer in an ice plant where the boiler was fed by a pump and an injector, each taking water from a different well, with no cross-connections on the system. As the well *A* was not often used, one could never be sure of its condition. It was really nothing more than a tank set in the earth and fed by water from a nearby spring. The pipe connection from the injector to the spring became partially clogged and I wanted the boss to clear it out so that we would always have enough water in well *A*; but he said that we had better use the pump and take the water from the reservoir *B*, which received the water from the condensing coils and was in reality a hot-well.



ILLUSTRATING "A TICKLISH JOB IN THE NIGHT"

At 2 o'clock one morning everything was going splendidly, when the feed-pump, the only one in the plant, refused to budge. The fireman, a green hand, after working with it until the water level dropped as much as the law allows, called for assistance to start the injector again. The injector would not always start promptly, as it had about all it could do to lift the water 15 feet and draw it through the horizontal distance of 100 feet from the well to the boiler. As good luck would have it, however, this time the injector started, but it was "nip and tuck" to keep the water level in the boiler, as the flow from the spring had almost ceased. Finally when the injector had taken nearly all the water from the well I saw it was up to me to shift to well *B* before the water got out of the boiler, or there would be a shut-down.

The pipe to well *A* lay one foot underground. Having only an old dim lantern to work with on a dark night, one may imagine how easy it was to see to dig up the pipe and find the unions to be disconnected. Then the strainer had to be taken out of well *A* and transferred to well *B*, this strainer being at the foot of the vertical suction pipe in the well. I got the pipe up all right and placed the strainer in the other well, but a bin filled with coal lay directly in the path of the pipe and there was nothing for it but to shovel out about half of the coal. The bin was five feet deep.

There was no vessel to catch the waste from the injector, so a pool of hot water had formed under the point where the last connection was to be made, at *C*. The corner of the boiler setting prevented the 2-foot pipe at the injector being turned in exact alinement with the long pipe section and the channel in the coal had not been made deep enough, so that a double bend had to be strained in the long pipe to enable us to install the union *C*. This work had to be done in the aforesaid pool of hot water, that being at the lowest point, where the ground was not capable of ready drainage after the trench for the pipe had been made. It was hustling work in the dark for thirty-five minutes for the fireman and myself, but at the end of that time the injector began to draw water and we thought we were heroes. We were satisfied that there would be no shut-down that night, but just as we started to put the water in the boiler the safety-plug over the fire-box blew out and the boiler had to be cooled down until morning. The next day it was found that some mischievous person had let all the water out while we were at breakfast and the boiler had to be entirely refilled by means of a pail.

E. S. HAWKINS.

Chicago, Ill.

A Useful Precaution in Electric Lighting Work and a Simple Method of Testing for a Short-circuit

The following hints are likely to prove helpful to those engaged in lighting work, especially in residential districts. The first cannot always be made use of, perhaps, but at times it is very convenient. It consists of putting several incandescent lamps in multiple and connecting them in series with the service switch and the lighting system in the house. This diminishes the voltage in the house and still allows the use of a few lamps which may be needed in halls or closets, etc., but it would not cause a dead short-circuit in case a workman should accidentally allow his tools to make a connection between some exposed portions of the circuit. A workman may also need some light where he is working, but as the total voltage might be inconvenient, the method here described for reducing it would be advantageous. Edison plug cut-outs or lamps of low candle-power would be found useful in such a case.

Another expedient which has proved to be very useful is a simple method of indicating whether a short-circuit has been remedied, by connecting a lamp in series with the defective circuit and the line. To illustrate its application and usefulness, suppose an electrician is called upon to remedy some trouble with the lighting system of a large residence. Upon arriving he finds that a number of lamps fail to burn, and his first conclusion is apt to be that the fuse on that circuit has burned out. Upon examining the distributing board it is found, perhaps, that two fuses have been burned out, the fuses being of the Edison plug type. The burned-out fuses are removed and one of them is replaced by a new fuse of the same capacity, if the case warrants it. The circuit is then completed through an incandescent lamp wired up to a receptacle plug which is inserted in the fuse-block socket instead of the other fuse plug. If the lamp burns brightly the short-circuit is still there, but if the lamp remains dark it indicates that the short-circuit was only temporary and a fuse plug can be substituted for the lamp.

The circuit should be carefully examined, however, to determine the cause of the short-circuit. Assuming the testing lamp to burn brightly, the electrician should examine all the lights, being first sure that none are turned on. Nine times in ten he will have no difficulty in locating the trouble, and as soon as it is remedied the test lamp will go out, and he can thus determine just where the short-circuit was.

E. S. LINCOLN.

Boston, Mass.

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Strenuous Central-station Practice

A 5000-kilowatt generator in operation at its rated capacity is putting out energy at the rate of 3,686,327 foot-pounds per second. Can you realize the potentiality which lifts over eighteen tons at the rate of one hundred feet per second, or considerably more than a mile a minute? When a unit of that kind goes wrong and this amount of energy is centralized on one point, as a burn-out or short-circuit, there are things doing which put the attendants on their mettle, and well-trained and cool-headed indeed is he who instinctively turns to the right lever or valve and does on the instant the thing which should be done.

Perhaps the most impressive demonstration of this kind which central-station practice has yet produced occurred on Saturday evening, April 20, at the Waterside station No. 1 of the New York Edison Company. Shortly after 9 o'clock, while on the peak of the load, one of the 5000-kilowatt turbine generators broke down, and at the same instant one of the 4000-kilowatt engine-driven generators burnt out, and the engine of still another 4000-kilowatt unit broke its low-pressure crank and knocked out a cylinder head. The short-circuited generators were ablaze and the station was filled with noise, steam and lightning.

The two Waterside stations, which had been operating in parallel, were separated and a part of the load transferred to Waterside No. 2, while the liberal provision of storage batteries enabled the operators to keep the voltage up to normal on most of the circuits. Current from No. 1 was restored in about fifteen minutes. About midnight the Curtis turbine in station No. 2 lost its vacuum, throwing a heavy overload on the Westinghouse unit, under which it broke down in less than an hour.

Notwithstanding this chapter of accidents there was very little interruption to the service. Some parts of the system, notably the down-town section, were not affected at all, and the lowest distribution pressure in a small section of the system, and that for a few moments only, was about 80 volts.

The management positively refuses to discuss the cause and manner of the accident, or to make any statement beyond a mere admission that the above-mentioned events did happen, and expressing adulation for the system which stood it without being crippled. It does not necessarily follow that the frankness which the interested engineering world would appreciate would throw discredit upon anybody's apparatus or the company's management of it, but it would look better for both the apparatus and the company if such a statement as would satisfy the legitimate interest of electrical and steam engineers in such an occurrence were forthcoming.

Burning Ashes

If one wanted to think out an expression which would suggest the absolutely and ridiculously impossible, what better could he hit upon than the title of this article? Ash represents the acme of incombustibility, the dross of the coal pile which is left when everything combustible has been burned out.

To talk of burning ashes is as absurd as to talk of burning water, or shoveling smoke, or eating air.

And yet since our article upon the subject under the title of "Bread from Brickbats" in the last issue appeared the country seems to have gone crazy upon the subject. An Altoona cobbler announced that after a lifetime devoted to the development of an idea bequeathed to him by his father he had discovered a combination of chemicals which, sprinkled upon a mixture of one part of ashes to two parts of coal, would endow the mixture with heat-producing properties exceeding those of an equal amount of pure coal. The magic compound was afterward announced to consist of common salt, oxalic acid and water; and the number of engineers, who, with affectations of skepticism but still with a sufficient credence in the possibilities of the thing to try it out, have cleaned out the kitchen salt box and exhausted the corner druggist's supply of oxalic acid, would make an astounding list if they could be but known. One of them, when asked how he came out, replied that it made "hell's own fire," but it took him all the afternoon to chip the clinkers out of the grate.

Another has out-Ellmored Ellmore, for instead of using one-third ashes to two-thirds coal, he used one part of coal to three parts of ashes, with a saving of over 60 per cent., in view of which Mr. Ellmore's champion (see page 385) need not have been so emphatic in his restriction of the cobbler's claims.

The opinions of several eminent auhorities upon the subject will be found on page 384.

The Rotary Engine

The rotary engine has been a seductive subject for the inventor ever since the steam engine has had an effective existence. James Watt, father of the reciprocating engine, begat also a rotary; but it evidently "died a-borning," for nothing remains of it save the patent record. Was it because the master put more virility into the reciprocating type, because the state of the art was inadequate to the realization of the possibilities of the rotary, or because the rotary possesses inherent defects and difficulties which are not common to the straight cylinder, and which successive generations of inventors have failed to overcome?

Perhaps the persistence of the reciprocating type and the failure of the rotary, through something more than a century of effort, to make a serious inroad upon its domain may be due not to the failure to produce an efficient type of rotary, but after all to a failure of the rotary to realize the anticipations which had been built upon it.

What is the rotary engine expected to do that the reciprocating engine does not do as well or better?

There seems to be an instinctive impression that there is a great saving to be attained by generating the rotary motion direct, instead of generating it in the straight line of the piston and crosshead movement, and then transforming it into the rotary. This assumes the crank to be an inefficient method of power transmission, whereas in point of fact it is extremely efficient, and engines are common which send out upon the belt or shaft more than 95 per cent. of the power generated in the cylinders. No device could reduce the friction of the mechanism much; the rotary engine, on account of the small piston area afforded and, thus, the large ratio of the frictional to the operative force, makes a worse instead of a better showing in this respect.

The complexity of packing pistons, different portions of which move at different velocities, increases the friction and makes leakage likely, while any practicable form of abutment involves a clearance which will be a large proportion of the small volume generated. We doubt if there has ever been a rotary engine invented outside of the turbine which approached the reciprocating engine in efficient use of the working fluid.

But mere cost of operation is not always the main object. Compactness, high speed without the vibrations due to the motion of reciprocating masses, lightness, simplicity, low first cost may be objects which outweigh heat, steam or mechanical efficiency. For traction work a light rotary engine that would not be prohibitively extravagant in fuel and repairs would find a waiting field, and this is true of some other special applications; but that there is an "aching void" awaiting the production of a practical rotary engine is a popular delusion which is being exploited "to the limit" by stock schemers with rotary engines as their stock in trade. There is no particular advantage to be looked for in a rotary engine, outside of the mechanical advantages indicated, and the blazing advertisements announcing such inventions as transcendent strokes of genius, miracles of simplicity, and the last final completion of the steam engine are such ridiculous and absurd exaggerations that the reader will do well to notice that it is the stock and not the engine which is advertised, and put the extravagant claims for the probabilities of the stock on a par with those for the engine.

Charge for Steam Supplied to Tenant

Recently several correspondents have asked for the "standard rate of charge," or a "fair rate of charge," for steam supplied to tenants for manufacturing purposes. They all want to reduce it to horse-power and charge by that unit.

The evaporation of 34½ pounds of watre per hour from and at 212 degrees, or any equivalent amount from and at other temperatures, is generally recognized as a horse-power. If a boiler delivered 3000 pounds of steam per hour at 120 pounds pressure, it would be credited with 104.33 horse-power if the feed were supplied at 62 degrees, but only 90.75 horse-power if the feed were supplied at 212 degrees.

If this 3000 pounds of steam per hour is sold to a tenant, shall he be charged for 90 or 100 horse-power? It makes no difference to him what the temperature of the feed is. It makes a difference to the seller, it is true, and the charging for more horse-power instead of for the same horse-power at an increased price per unit is an indirect way to adapt his charge to the conditions of manufacture; but the customer, who uses 3000 pounds of steam per hour and does not care how it is made nor what it is made out of, is put in the position of using some 90-odd horse-power in one case, and 100-odd in another. While his consumption of steam is perfectly uniform, his consumption of horse-power would flicker with every variation of the temperature of the feed-water.

Again, suppose the tenant required the steam to be at only 10 pounds pressure. A boiler which made 3000 pounds of steam per hour from feed of a temperature of 212 degrees would be credited with 87.72 horse-power; from a temperature of 62 degrees, with 101.31. If the tenant returned the condensation at 212 degrees, and in fit condition for use in the boiler, he might consistently be charged with but 87.72 horse-power against 101.31 if he did not return the condensation. This deals merely with the heat in the water. If, as in cities, the water itself is worth something, its return or non-return makes a still greater difference. If the owner instead of making the steam at 10 pounds makes it at 150 and runs it through an engine exhausting it at 10 pounds and sends the customer the exhaust steam, over 90 per cent. of it will be available for delivery to his customer in this way, and the owner's power will have cost him practically no fuel. If he charges himself with the regular cost for power, the exhaust steam costs him very little and he can afford to sell it correspondingly cheap.

Furthermore, there is the question of continuity of supply. For power, a tenant is ordinarily charged for his maximum demand. If it requires 10 horse-power to run his shop, he is charged 10 horse-power whether he runs it full all the time or, as usual, only partially running most of the time. The landlord justifies this by claiming that he is selling not a commodity but a service, not so many foot-pounds of energy going over a belt or through a pipe, but the services of a boiler and engine and an engineer standing ready to make, if necessary, power up to the amount contracted for.

This argument is justifiable perhaps, but many a man is selling two hundred horse-power from a one hundred horse-power outfit as a corollary of it.

The up-shot of all of this is that it is not to be expected that there can be anything like a standard or general charge. The landlord or seller should determine what extra expense he would be put to by the demand in question and charge a fair profit above that figure. What he will do is to charge the tenant all he will stand without getting out or making some other arrangement for his steam supply.

Save the Water Powers

If when this country was developed the stores of coal disclosed had been taken in trust by the people for the use and benefit of the people, instead of having been seized by the one who saw them first for his own benefit, there would be a different situation in the matter of fuel today. But there is one thing that the State does control and that is the water in the rivers, and the development of the possibilities of long-distance transmission is making the potential energy of this water as valuable as that of coal.

It behooves the people, however, to guard their rights in these sources of power and to prevent their acquisition for merely nominal considerations by private interests.

The calendars of Congress and the different state legislatures are already full of bills granting to this and that company the privilege of developing this and that water power, and the representatives of the people should be warned not to surrender the people's rights in these sources of energy, to be exploited and retailed back to them at exorbitant prices, but only under such restrictions as will make that energy available for common use at prices which will pay a fair return upon the money actually invested in its development.

Notice

Hereafter the subscription price of POWER to Canada will be $2.50, postage paid. This increase in price is made necessary by the new postal treaty increasing the postage rate to Canada a little matter of 400 per cent

The Uehling Gas Composimeter

This instrument shows at a glance the quality of the flue gas, the latter being an index of the completeness of combustion. When the carbon of the fuel is completely burned the product is carbon dioxide, or carbonic acid gas. The gaseous products of combustion consist of this carbon dioxide, the nitrogen of the air taken into the furnace and deprived of its oxygen by the combustion of the carbon and the excess of air admitted over that theoretically required to effect the combustion. The more complete the combustion and the less the excess air, the greater the percentage of carbon dioxide in the flue gases, and as both of these conditions are favorable to economy, the greater the percentage of CO_2 the better the efficiency.

Several instruments have been devised to indicate the percentage of CO_2, that under review being based upon the law governing the flow of a gas through two small apertures. This law may be illustrated by a small diagram, Fig. 1, representing two chambers C and C' which are in communication with each other through the aperture B, and with the source of gas through the aperture A; C' is connected with an aspirator D as shown. The monometers p and q indicate the gas tension within the respective chambers.

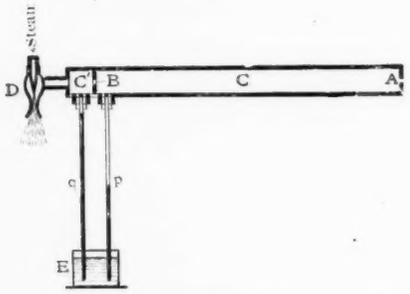


FIG. 1. ILLUSTRATING THE LAW ON WHICH THE PRINCIPLE IS BASED

The aspirator set in action, a vacuum is created in the chamber C', the gas will flow from C through B to C', creating a vacuum in C, which will cause gas to enter through A, thus establishing a continuous flow of gas through both apertures. If a constant vacuum of, say, 48 inches be maintained in the chamber C', and the two apertures A and B are of the same size and are maintained at the same temperature, the monometer p will show about one-half the vacuum maintained in C', due to the fact that the apertures oppose equal resistance to the passage of the gas. This relation will be maintained as long as the same volume of gas flows through B that enters through A.

If, however, a constituent of gas be continuously taken away or absorbed from the gas in passing through the chamber C, the vacuum therein will be correspondingly increased. This increase of vacuum in C, shown by the monometer p, therefore correctly indicates the volume of gas absorbed and in the gas composimeter is utilized to indicate the percentage of the constituent of the gas to be determined.

To embody the principle described into a practical apparatus, the following conditions must be fulfilled: 1. The gas must be brought to the instrument under a constant tension and must be drawn through the apertures with a continuous and uniform suction. 2. Both apertures must be located in a medium of constant temperature. 3. Provision must be made that the apertures remain perfectly clean. 4 The chamber C must be made perfectly tight so that no gas can enter, except through the aperture A. 5. The constituent to be measured must be completely absorbed after the gas passes through A, and before it passes through B.

Fig. 2 is a diagrammatic view of the gas composimeter illustrating how the conditions enumerated are practically met.

The regulator consists of a cylinder H, 8 inches in diameter and 5 feet high, filled with water, as shown, into which project the tubes a a', b b' and c c'. The tube a a' is open to the atmosphere at a and extends to within a few inches of the bottom of H. The end of the tube b b' is exactly 48 inches above the lower end of a a' and the lower end of c c' is just 6 inches above the lower end of a a'. The cylinder is filled with water so that the tube b b' is submerged several inches. The gas inlet J which connects with the source of gas communicates with aperture A through D, f, k, F, g, and also communicates with the regulator H by means of a pipe c c' which joins pipes f and k at 12.

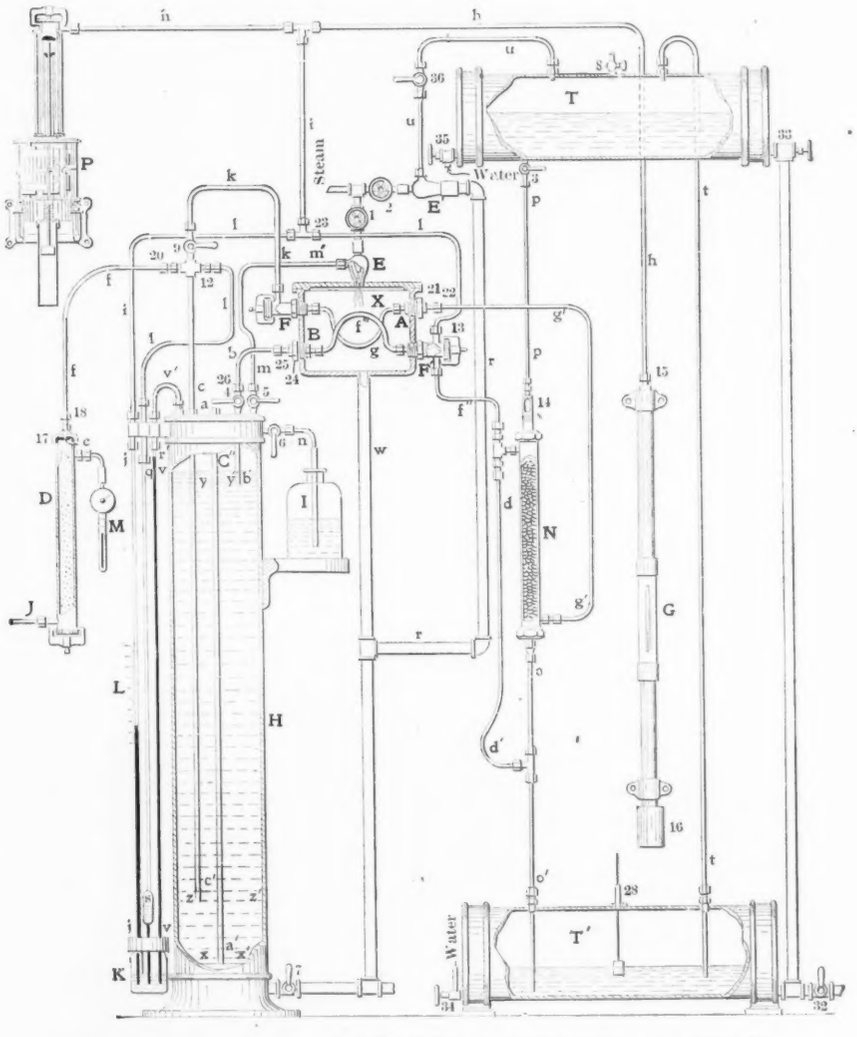


FIG. 2. HOW THE GAS COMPOSIMETER IS CONSTRUCTED AND OPERATED

If valve 1 is opened, the aspirator E is started, suction is created through the pipe m m' in the chamber C'' above the water, which suction increases until the pressure of the atmosphere overcomes the pressure of the water column in the tube a a' when air bubbles through the water into C''. The air thus entering satisfies the aspirator and prevents any further increase in suction, and neutralizes irregularities due to change in steam pressure, etc.

It is evident, that so long as the suction is sufficient to draw air through a a',

the horizontal plain of water *x x'* in which the pipe *a a'* terminates is under atmospheric pressure. The plain *y y'* lying 48 inches above *x x'* is under a suction of 48 inches and the plain *z z'* being 6 inches above *x x'* is under a suction of 6 inches of water. Therefore the contents of tube *b b'* corresponding to chamber *C'*, Fig. 1, must be under a constant suction of 48 inches of water, similarly the contents of tube *f c c'*, from which the gas flows to aperture *A*, is under a constant suction of 6 inches of water.

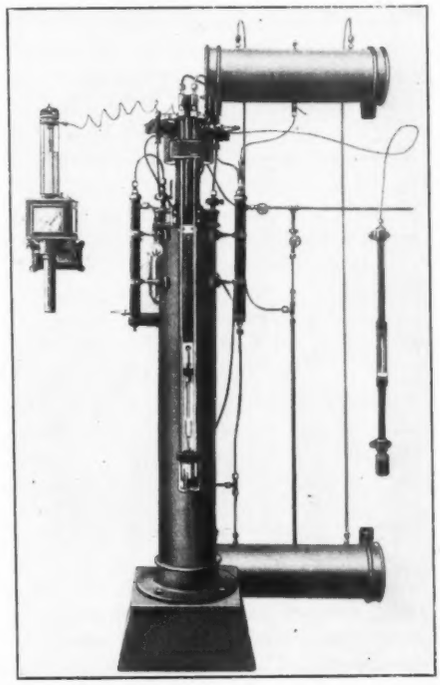


FIG. 3. THE UEHLING GAS COMPOSIMETER

Aperture *e* at the upper end of the filter *D* is so gaged that more gas will pass through it than can pass through the aperture *A*, and still not be sufficient in quantity to destroy the 48-inch suction in the tube *b b'*. The excess escapes at *c'* and bubbles up through the water into *C''*, from where it is drawn off together with the air entering at *a a'* and the gas from which the CO_2 has been absorbed entering at *b'*.

This arrangement fulfils condition 1 perfectly so long as the water level in *H* is not allowed to fall below the plain *y y'*. When this occurs the water must be replenished from jar *I* by opening the cock 6.

Condition 2 is fulfilled by placing both apertures *A* and *B* in a chamber *X* which is kept at a uniform temperature of 212 degrees by the exhaust steam of the aspirator *E*, which is permitted to escape at atmospheric pressure through the pipe *w w*.

Condition 3 is met by placing a large filter, not shown, at the source of the gas supply, together with cotton filters *D* and the small filters *F* and *F'* before each aperture by which the gas is perfectly cleaned and the apertures protected from being fouled.

Condition 4 is fulfilled by having the chamber *C* composed of all the tube connections, and chambers, between apertures *A* and *B*, all these connections consisting of drawn copper tubing, the joints of which are accurately made and carefully tested so that no leak can occur.

To meet the requirements of condition 5, the absorption tube *N* is provided to remove the element to be determined from the gas drawn through the apertures with certainty, a continuous supply of an efficient absorbent flowing in the opposite direction and exposing an abundant surface.

Chamber *C* of Fig. 1 is in Fig. 2 composed of the pipe *g'*, absorption chamber *N*, the pipe *f''*, filter *F'*, the pipe *f'''* and the pipe *i* branching off at *13*. To the latter is connected the monometer tube *j j*, the recording gage *P* through the pipe *h'*, and the observation gage *G* through the

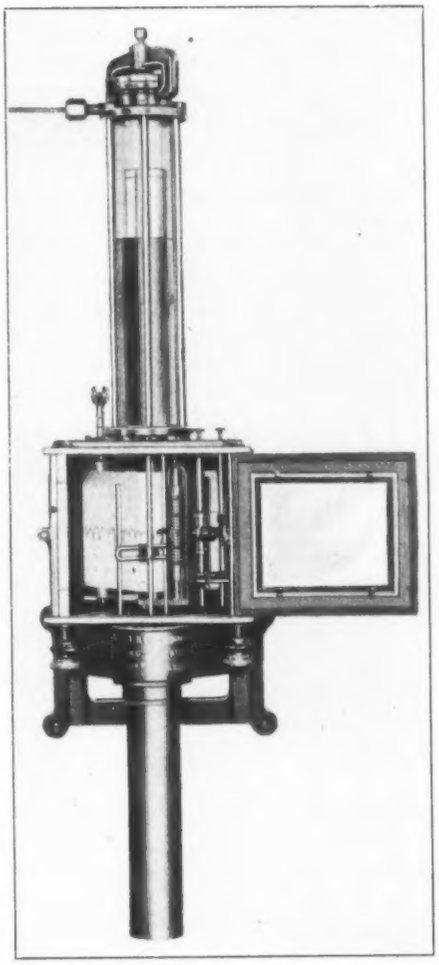


FIG. 4. RECORDING GAGE

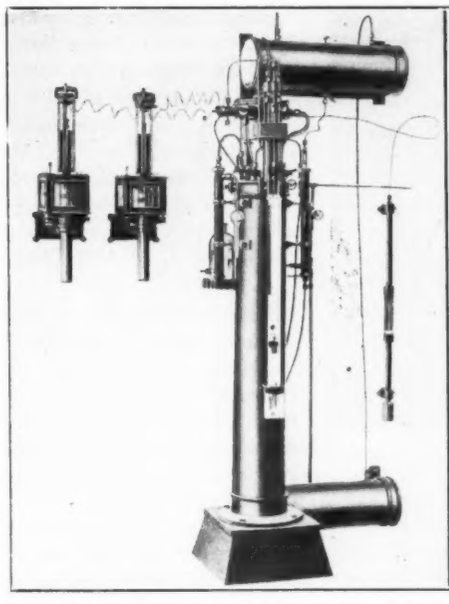


FIG. 5. PYROMETER AND GAS COMPOSIMETER

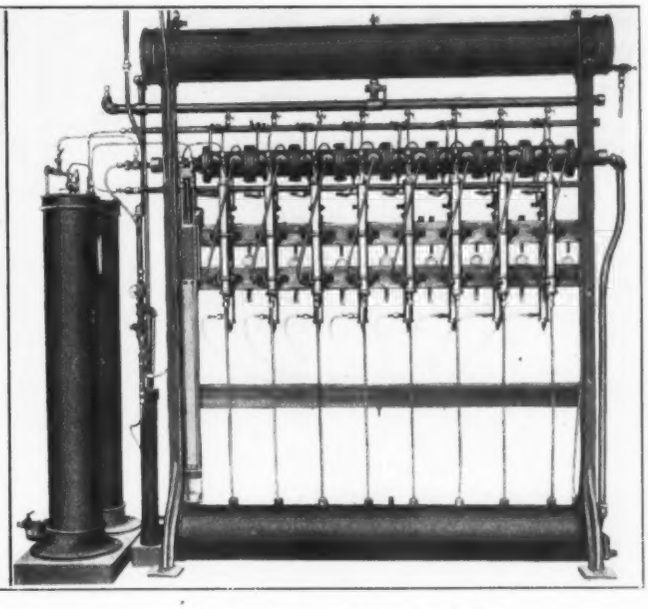


FIG. 6. MULTIPLE GAS COMPOSIMETER

pipe *h*. The monometer tube *j j* and gage *G* are so calibrated that the suction between apertures *A* and *B* can be read off in per cent. of CO_2 contained in the gas.

The tube *h* connecting the gage *G* may be extended so that the gage can be placed at a point most convenient for the fireman or attendant for whose guidance it is to serve.

The water in the monometer tube *v v*

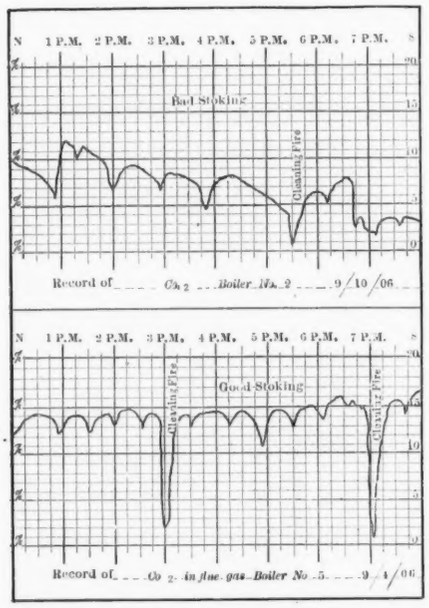

N 1 P.M. 2 P.M. 3 P.M. 4 P.M. 5 P.M. 6 P.M. 7 P.M.
Bad Stoking
Cleaning Fire
Record of ... Boiler No. 2 ... 9/10/06
N 1 P.M. 2 P.M. 3 P.M. 4 P.M. 5 P.M. 6 P.M. 7 P.M.
Cleaning Fire
Good Stoking
Cleaning Fire
Record of ... Co 2 in flue gas Boiler No 5 ... 9/1/06

FIG. 7. RECORDS MADE BY THE UEHLING GAS COMPOSIMETER

shows the hight of water in the regulator *H* above the line *x x'* and must be kept above the index *r'*.

The water level in the glass *s* shows the 6-inch suction, and the water levels in the U-tube *M* show the resistance in the line plus the chimney draft.

The operation of the gas composimeter is as follows: Opening valve 1 starts the aspirator *E*, a vacuum is created in chamber *C''*, which causes the flow of gas through the system. An excess of gas enters through *J*, *D*, and the aperture *e* into *f*. and the quantity not required for analysis escapes through *c c'* into *C''* direct. A continuous sample flows from *f* through *k* to *F*, from *F* into *g* where, surrounded by the exhaust steam from the aspirator *E*, it is heated to 212 degrees, thence passes through aperture *A* and through *g' g'* into the absorbtion tube *N*, where the constituent to be determined is absorbed by a suitable re-agent. From the absorption tube the remaining gas flows through *f''* and *F'* into *f'''*, where it is again heated to 212 degrees, thence passes through aperture *B* and by way of *b b'* into chamber *C''* from where it is continuously removed by the aspirator together with all other gases entering the chamber. The absorption tube *N* is filled with quartz pebbles. For the continuous analysis of gas for CO_2 the surfaces of these pebbles are kept moist by continuously dropping a dilute solution of caustic soda or potash upon them, which flows from the tank *T* through the pipe *p*. The flow is regulated by the cock 3, and can be observed through the sight feed at *14*.

The absorbing solution flows from *N* through *o o'* into the receiving tank *T'*. Pipe *d* is simply to guard against the possibility of any absorbent reaching filter *F'*. When *T* is nearly empty the solution is lifted back by closing the cocks 3 and 8 and opening valve 2, thus creating a vacuum in *T* by means of the aspirator *E'*. This operation is repeated each time *T* is empty, until the solution has become saturated, after which a fresh solution must be supplied. When the solution in the tank *T'* has been lifted to *T* cock 8 should again be opened.

The gas composimeter is continuous in its operation, the water column in *j j* and that in observation gage *G* varies in hight in front of a scale graduated to show the percentage of CO_2 contained in the gas passing through the instrument, and the recording gage makes a continuous autographic record of the same.

In its practical application, the main instrument and recorder are placed in any convenient place within reasonable distance from the boilers, away from the dust and dirt of the boiler house. The indicators are placed on or near the boiler front, in plain view of the fireman, who can thus at all times see at a glance, the

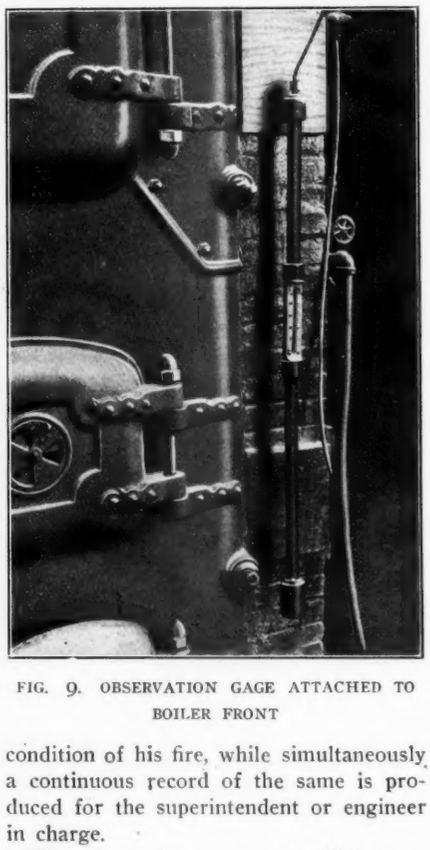


FIG. 9. OBSERVATION GAGE ATTACHED TO BOILER FRONT

condition of his fire, while simultaneously a continuous record of the same is produced for the superintendent or engineer in charge.

The pneumatic pyrometer, which operates on the same principle, is readily combined with the gas composimeter, and with it the temperature of any part of the boiler setting can be indicated and recorded, simultaneously with the percentage of CO_2. If the pyrometer be placed so as to indicate the temperature of the flue gases as the latter leave the boiler, the two principal factors of fuel economy are determined.

Fig. 3 illustrates the gas composimeter in single form; Fig. 4 is a recording gage, such as produced the records shown in Figs. 7 and 8, and Fig. 5 shows the combined pyrometer and gas composimeter.

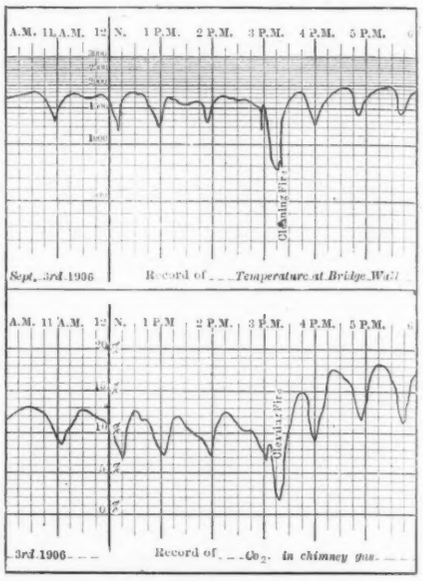

A.M. 11 A.M. 12 N. 1 P.M. 2 P.M. 3 P.M. 4 P.M. 5 P.M.
Cleaning Fire
Sept. 3rd. 1906 Record of ... Temperature at Bridge Wall
A.M. 11 A.M. 12 N. 1 P.M 2 P.M. 3 P.M. 4 P.M. 5 P.M.
Cleaning Fire
3rd. 1906 Record of ... Co_2. in chimney gas.

FIG. 8. RECORDS MADE BY COMBINED PYROMETER AND GAS COMPOSIMETER

Where a plant consists of a number of units to be individually controlled, the multiple system of composimeter, illustrated in Fig. 6, is used. A system may consist of any number of units up to sixteen. The observation gage referred to is shown in position in Fig. 9.

Referring to Fig. 5, the proper place for the pyrometer, in connection with a boiler, is where it will give a continuous record of the temperature of the gases just as they leave the boiler, at which place, in connection with the CO^2 record, they complete the measure of economy.

Duplex Water-tube Boiler

In the "Duplex" water-tube boiler, which is illustrated herewith, the features which are most strongly emphasized by the designers are: Delivery of steam from the boiler in a superheated condition, without the use of a special superheater; removal of steam from the boiler at a point where there is no ebullition, and elimination of a great many parts of the undulating-header type of boiler. The design of the boiler shows absence of stay-bolted surfaces, the drums are not exposed to the direct action of the fire, all seams or rivets are entirely removed from contact with the heat, rigid connections are avoided between parts, and all joints are expanded.

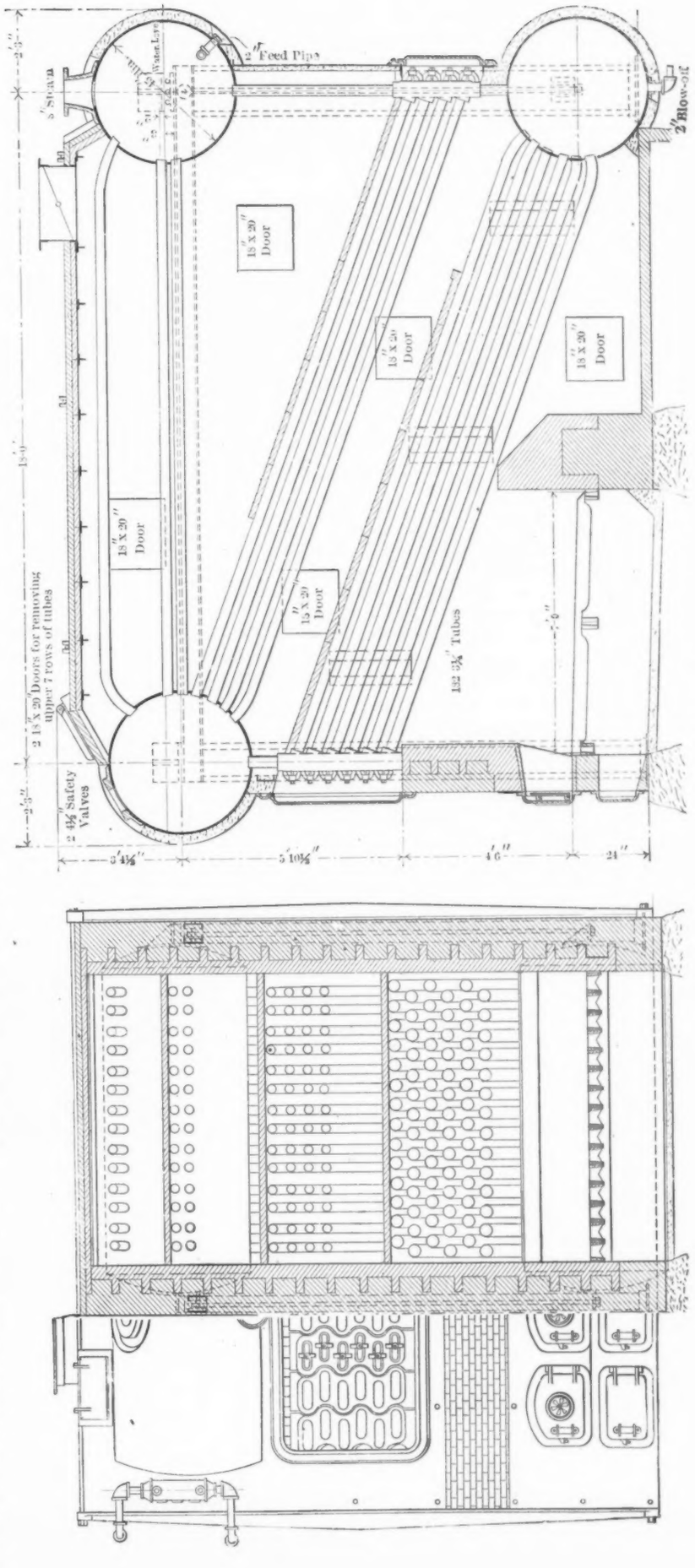
The "Duplex" boiler consists of two upper steam drums connected by tubes. Short tubes expanded into the bottom of the shell of the rear drum form the connection to a set of headers below it, which are connected to the front drum by tubes expanded into the shell of the latter. This comprises the upper generating system. These headers are likewise connected to a drum situated below them by short nipples, and this lower drum is in turn united to a set of headers below, and similarly connected to, the front drum. This comprises the lower generating system. The tubes are inclined 20 degrees to insure rapid and positive circulation.

The drums are made in one sheet with no circular seams except those connecting the heads to the shell. The longitudinal seams are butt-strapped, either double or triple riveted, as the pressure demands, and located on the outside of the shell. A pressed-steel manhole is placed on the circumference of the shell for access to the interior of the drums.

The headers are heavy, made of open-hearth steel, and the section of the header to which the handhole plates are secured is designed to be extra heavy, as is that portion where the tubes enter the header, this latter being intended to provide a wide tube seat and obviate the danger of leaky tube joints. The headers are of long box-like form and each header is designed to take in two vertical rows of tubes. An elliptical handhole is placed opposite the ends of two tubes through which the tubes are cleaned or removed. This handhole is closed by an elliptical cap inside the header held in position by a bolt secured with an outside crab. The joint between the cap seat and the header is made tight with an asbestos gasket to avoid the necessity of remilling the contact surfaces every time a cap is removed and replaced. In this construction the bolt and crab are relieved of the strain of the boiler pressure.

The boiler tubes are 3¼ inches in diameter, of either charcoal-iron or steel lap-welded, expanded directly into the shell of the drums or into the headers, and the ends are belled over one-quarter of an inch.

A heavy steel framework incased in the brick setting supports the boiler. On the sides and independent of the boiler are built walls of brick about 17 inches in thickness. The rear of the boiler is fitted with a sheet-iron casing protected with asbestos covering, the boiler being roofed over with fire-tile supported by heavy T-irons. The boiler fronts are of steel and doors of ornamental design are provided for access to the headers. The framework is so designed as to provide for the free expansion of all the tubes. The two upper drums are set on lugs secured to the heads, the lugs in turn being supported by the steel framework. The rear lugs are first set on rollers which allow for the



SECTIONAL FRONT AND SIDE ELEVATIONS OF "DUPLEX" WATER-TUBE BOILER

expansion of the tubes connecting the two drums.

The horizontal style of baffling is used. These baffles rest on the tubes and guide the gases along the lower bank, thence along the upper bank and the horizontal circulating tubes; finally the gases pass through the smoke outlet, which may be situated on the top of the boiler at the rear or at a point just under the rear drum. The course of the gases is always upward, which is the free and natural passage for them. The baffles are of the common rectangular shape, which any dealer carries in stock.

The upper and lower banks of tubes comprise the active heating surface of the boiler. The tubes that form the lower system are connected at their rear ends to a large mud-drum, which acts as a reservoir for water, to insure an ample supply for the bottom tubes at all times. The upper bank is arranged in reverse of the lower, the tubes being connected to the front drums at their front ends. All the tubes of the upper system discharge independently into this drum. The header ends of both banks of tubes are connected into headers that are straight and of ample area. As the gases pass along the tubes instead of across them, the tubes are not staggered, and this permits of access to all of the tubes for the necessary scraping of soot that has been baked on in service.

The feed-water is introduced in the upper rear drum, where any air that it contains may be liberated. It then passes downward through the rear circulating tubes and headers to the lower rear drum, where any impurities present in the feed-water may be deposited. The passage of the water is then upward through the lower bank of tubes through the front headers to the front drum. At this point any steam that is generated separates from the water and passes across the steam tubes to the rear drum and is believed to be thoroughly dried out and superheated slightly in the process by coming in contact with the hot gases surrounding these tubes. The water passes across through the horizontal circulating tubes to the rear drum, thence downward again to the rear headers, and thence up the upper bank of tubes into the front drum again. By this time it is expected that the water will have become heated to a very high temperature and, becoming steam, it passes to the rear drum through the superheating tubes, being superheated on the way. From this rear drum the steam is withdrawn, there being no ebullition at this place, as experiment with a boiler with glass heads on the rear drum has shown.

The safety valve is located on the front drum, where its sudden operation cannot throw water into the steam opening. The spaces between the banks of tubes provide access to all parts of the boiler inside the setting through doors in the setting, and other openings in the setting permit the boiler tubes to be cleaned by blowing with steam or compressed air.

The designers have been carrying on experiments with this boiler for the past year, the results of which were published in April POWER under the title of "Watching a Boiler at Work." It is the property of the Power Development Company, 20 Central street, Boston, Mass., and the builder is the Robb-Mumford Boiler Company, South Framingham, Mass.

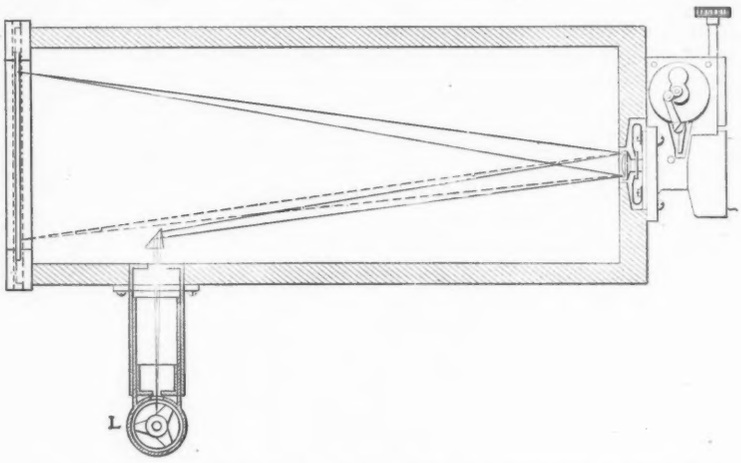


FIG. 1. SECTIONAL PLAN VIEW OF HOSPITALIER-CARPENTIER MANOGRAPH

The Manograph; a Continuous Gas-engine Indicator

BY HOWARD GREENE

Taking indicator diagrams from a fast-running gas engine is a practical impossibility with an indicator of the type commonly used in steam-engine work, because at gas-engine speeds the reciprocating parts of the indicator possess sufficient inertia to cause them to overrun at the end of a stroke and to lag at the beginning, producing inaccurate curves. In order to provide means for ascertaining what occurs in the cylinder of a gas or oil engine, the late Professor Hospitalier devised an instrument called the manograph, which draws on a ground-glass screen a diagram such as would be made by an ordinary indicator if the inertia of its moving parts could be reduced to a negligible value. The operating principle of the manograph is simple. A small mirror is tilted upward and downward by a diaphragm which responds to the pressure variations in the cylinder, and the same mirror is rocked from side to side by a reducing mechanism which is geared to the engine and reproduces the reciprocations of the engine piston on a smaller scale. A beam of light is reflected by the mirror to the ground-glass screen, and this beam, by the oscillations of the mirror, is made to traverse the path corresponding to that of the pencil point of an ordinary indicator. The diagram, therefore, is made continuously but varies with varying conditions in the cylinder.

Fig. 1 is a sectional plan view of the manograph and shows the general disposition of its parts. The box is 14½ inches long, 6 inches wide and 5 inches high, and at the left end is a ground-glass screen in a removable frame. In the opposite end is a small opening through which the little mirror, only half an inch in diameter, projects the beam of light; on the outside of this end of the box is a brass plate carrying the mechanism for moving the mirror. An acetylene gas burner or electric arc lamp *L*, carried in a brass tube, throws a ray of light through a small aperture in a diaphragm

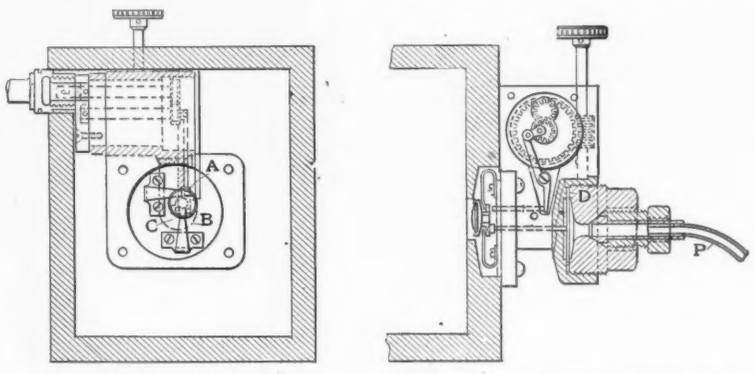


FIG. 2. DETAILS OF MIRROR-MOVING MECHANISM AND SHOWING SYNCHRONIZING GEAR

to a prism which deflects the light to the mirror, whence it is thrown on the screen.

The mirror-moving mechanism is shown in detail in Fig. 2. The slight movement required of the mirror to indicate pressure variations is produced by the explosion pressure carried through a pipe *P* and acting on a flexible steel diaphragm *D*, from the opposite face of which a tiny steel rod extends to the back of the mirror, tilting it upward as the diaphragm is caused to bulge under pressure. When the pressure is removed the mirror is brought back by the springs shown. The diaphragm is calibrated, of course, so that it is known exactly how high the beam of light on the ground glass will rise under a given pressure in the cylinder, and scales sent out with the instrument are used to take direct readings.

It is not usually practicable to obtain the horizontal rocking motion, representing the piston stroke, directly from the piston or other reciprocating parts, so connection is made with the crank-shaft by means of a screwed-in plug with a tapered projecting part which receives a correspondingly tapered socket carrying a little universal joint on the end of a flexible shaft extending to the instrument. The rotary motion of the flexible shaft is converted to reciprocating motion by the gears, crank and lever shown in Fig. 2, and the oscillations of the lever are transmitted to a little steel rod, which gives horizontal motion to the mirror. The back of the mirror rests against three points, two of which are the ends of the little rods that move it, and the third

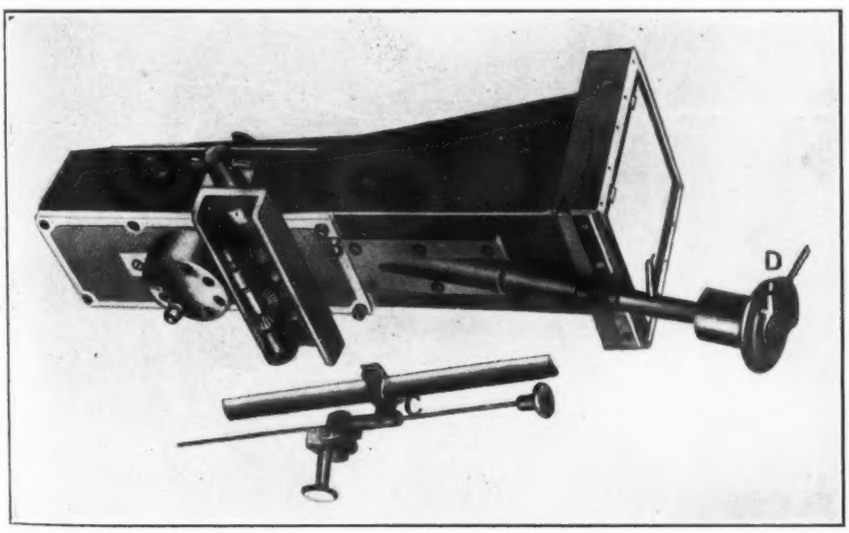


FIG. 3. SCHULZE MANOGRAPH WITH NERNST LAMP AND DRIVING SHAFT AND GEARS

a stationary point. The three points are arranged in the form of a right-angle triangle *A*, *B*, and *C* (see left-hand drawing, Fig. 2), with the fixed point *B* at the 90-degree angle.

It is, of course, difficult to ascertain the exact relative positions of the piston of the motor and the stroke-reproducing mechanism of the manograph; neither is it necessary, and connection is made by means of the taper socket and plug at random. But the strokes must be brought together exactly, and this is done as follows: The gear directly driven by the flexible shaft is journaled in a bronze disk that can be rotated, carrying the gear with it, by a worm-and-gear arrangement operated by a milled head, as shown, without changing the position of the other gear, which is in a recess in the center of the disk. The rotation of the disk causes the outer gear to roll on the inner one, like a planetary gearing, and so advances or retards the rotation of one with relation to the other, until the piston stroke and its reduced fac-simile in the manograph exactly correspond. When the instrument is properly synchronized the ascending compression curve will correspond almost exactly with the descending expansion curve of the unignited charge, when the motor is turned over by external power or is run under its own power and then the ignition cut off and the curve watched on the ground glass while the engine turns over by momentum. If the curves do not correspond, the milled head is turned until they approach each other as closely as the leakage of the charge past the piston and valves will permit. Or, the engine may be run with ignition set so late that the charge will expand through a considerable part of the stroke before ignition occurs, giving an opportunity to compare the curves in the same way.

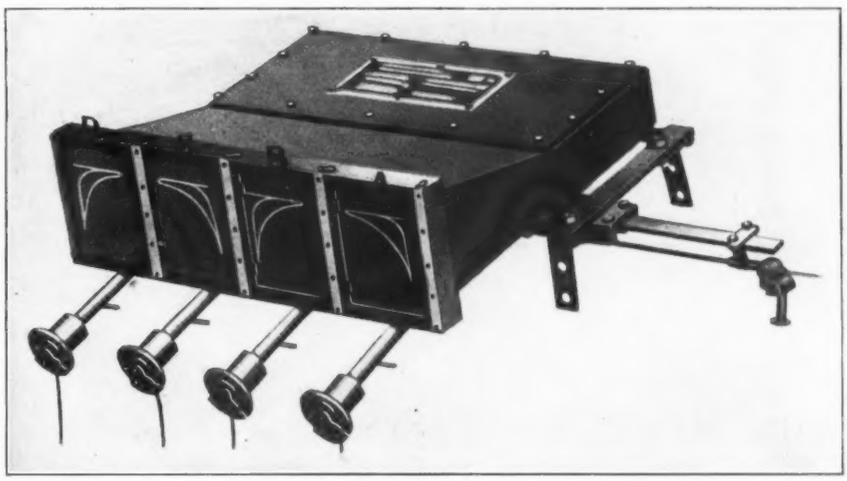


FIG. 4. SCHULZE QUADRUPLE MANOGRAPH FOR FOUR-CYLINDER MOTOR

A plate-holder carrying a photographic dry plate can be substituted for the ground-glass screen, and the diagram photographed, the exposure required varying from half a second to three seconds. The swiftly moving point of light on the glass does not appear to the eye as a continuous line until the speed of the engine reaches about 1000 revolutions per minute, but photographs can be taken at any speed. In addition to gas engines, steam engines can be indicated with the manograph, as well as air pumps, vacuum pumps and similar machines. By the use of special diaphragms and springs the effects of low pressures and vacuums can be magnified, and thus the instrument can be made to show with remarkable clearness the action of the valves of a gas engine on the suction and exhaust strokes.

Fig. 5 shows some diagrams taken with the instrument. At *A* is shown the sort of curves obtained when the mirror is not in synchronism with the engine piston; the diagram *B* was taken with the ignition retarded so as to get enough of the return curve to compare with the compression curve for synchronizing before the explosion occurs; *C* is a similar diagram, showing that the piston is lagging behind the mirror, and *D* is a corresponding diagram taken when the mirror is lagging behind the piston; the diagram at *E* indicates synchronism between the instrument and the engine and shows that the ignition is not advanced quite far enough; that at *F* shows the contrary condition of too great ignition advance.

The manograph just described is known

as the Hospitalier-Carpentier, and is made by the well known Carpentier instrument house in Paris. Another instrument, differing in constructional details, is the Schulze, made in Alsace-Lorraine. This has a stroke-reproducing motion obtained from the two-to-one cam-shaft, and transmitted to the instrument through rigid shafts and bevel gears.

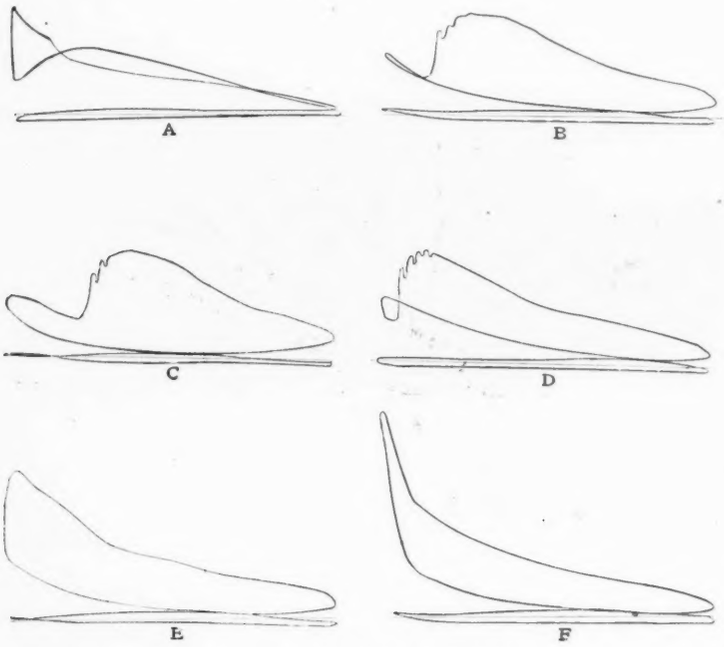


FIG. 5. MANOGRAPH DIAGRAMS

The Carpentier instrument is intended for portable use and is set up on a stout tripod, while the Schulze manograph is designed more as a fixture to be permanently mounted on or near the engine. The Schulze instrument is also made in quadruplex form, so that all the cylinders of a four-cylinder motor can be indicated and compared at the same time. Fig. 4 illustrates this form of the apparatus.

The pressure diaphragm is backed by a strong flat spring, its own elasticity not being relied upon. Synchronizing is effected by skipping teeth in a pair of very fine-toothed gears by a special device which skips one tooth at a time. A Nernst incandescent electric lamp throws a light directly on the mirror through a long tube; this is shown in Fig. 3, which also shows the gearing and shaft supports.

New Allis-Chalmers Railway Generator

Fig. 1 herewith shows the latest type of direct-current generator built by the Allis-Chalmers Company, Milwaukee, Wis., for railway power-house service. The machine is, of course, of the direct-driven type, the armature spider being mounted on the shaft of the engine which drives it.

The field-magnet yoke is of cast-iron, divided horizontally, and the inner surface of it is bored out concentric with the axis of the machine. The field-magnet poles are bolted to this bored-out surface. They are usually built up of laminations clamped between cast cheek-pieces, as indicated in Fig. 3, but in some cases cast-steel poles with laminated pole-shoes have been employed. In all cases, the field-magnet coils are wound on forms and individually insulated, as is now standard practice.

The armature is of the usual slotted-core type with a straight-out or "barrel" form of winding. Fig. 2 illustrates the construction of the core and spider, and shows the ventilated extension frames which support the parts of the winding that project beyond the core at both ends; in the engraving, the armature is shown mounted on a temporary shaft, used for assembling and truing up the parts. The armature coils are made of rolled copper strips, each coil being one continuous piece of copper. The coils are "made up" in groups, each group containing all the coils that go in one pair of core slots. The coils are insulated individually, of course, and then each group of coils is wrapped with insulating material; the insulated group is then put in a steam-heated press and the insulation

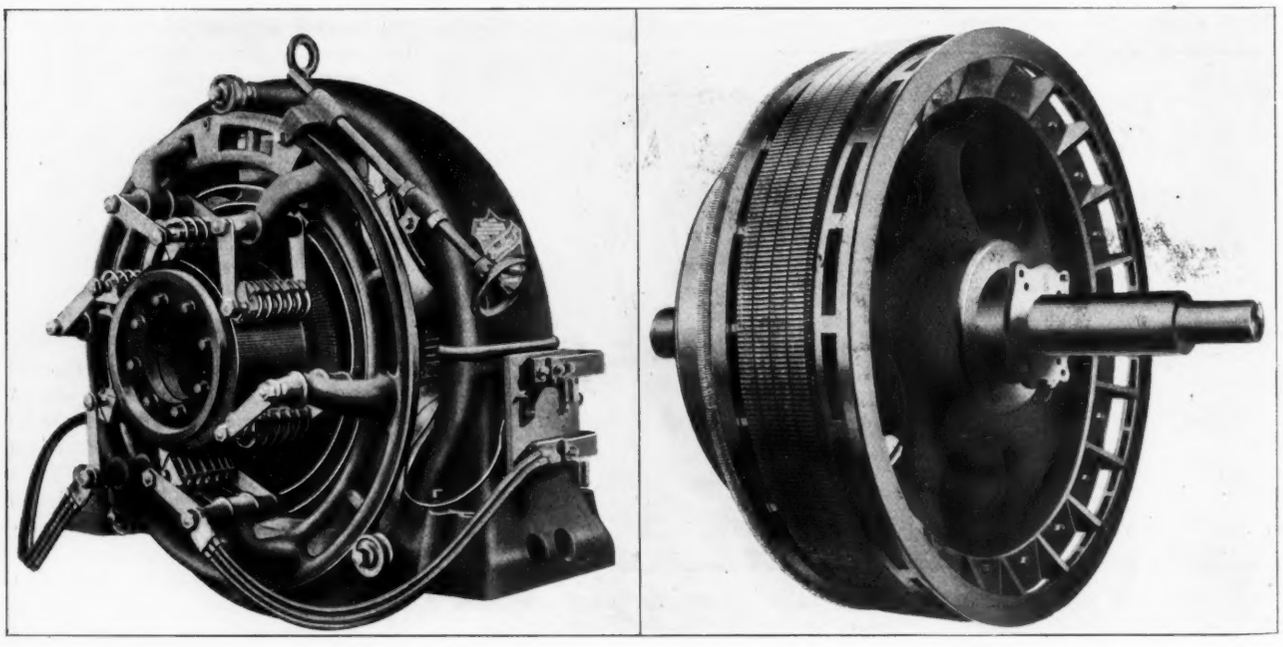


FIG. 1. NEW RAILWAY GENERATOR

FIG. 2. ARMATURE CORE AND SPIDER

compressed to a uniform shape. Fig. 4 shows two groups of coils for an armature of the multipath type, and Fig. 5 illustrates two groups of coils for a two-path armature winding.

The brush-holders are a modification of the well known reaction type, each brush being bolted to a clamp the ends of which

FIG. 3. A FIELD-MAGNET POLE

slide in grooves cut in the block or stationary part of the holder, as shown in Fig. 6. The brush-holders are mounted on studs set into but insulated from a cast-iron ring which is supported by several rollers mounted on the field-magnet frame, as shown in Fig. 1. These rollers are moved back and forth on their studs,

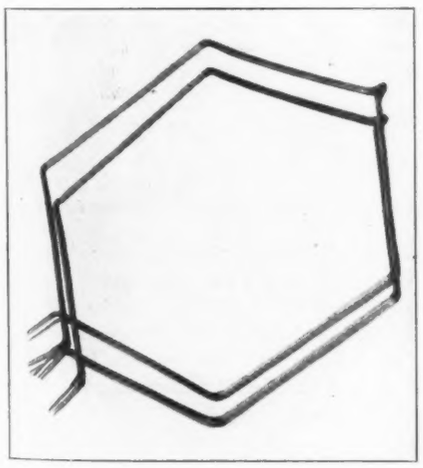


FIG. 4. ARMATURE COILS FOR MULTIPATH WINDING

through a distance of about ⅜ inch, by means of a system of gearing driven by a belt from the engine shaft (not shown here). This motion to and fro is very slow, and the result is that the brushes are slowly but continuously moved back and forth along the commutator face; consequently, the brushes do not tend to wear grooves or tracks in the commutator.

Some New Chesterton Packings

To meet the demand for a packing which will withstand high temperatures, as in gas-engine and superheated steam work, and which is impervious to acids and alkalis, as required for chemical processes and refrigerating plants where ammonia is used, A. W. Chesterton & Co., 64 India street, Boston, import "Vaporite," an indurated asbestos sheeting capable of withstanding a temperature of 1500 degrees Fahrenheit and which can be subjected to a pressure of 28,000 pounds without losing its efficiency. It comes in 48 x50-inch sheets, 1/32, 2/32, 3/32 and 4/32 thick, the weight per sheet being about six pounds per each thirty-second of an inch of thickness.

Another packing in which a metal wire is used is the "Metal-wove," in which a white metal wire is interwoven with asbestos. It is especially recommended for use on steam hammers, rolling-mill and blast-furnace engines, and is made as well in the spiral form.

For rod packings the Advance Packing and Supply Company (a "Chesterton" store) presents "Trio," consisting of four members of similar triangular section, as shown in the engraving, one of flax next to the rod, two of "wedges" on the side, and one of red rubber on the back to give the required elasticity. When the packing is taken up the wedges slip over each other, as shown, increasing the hight as the width is lessened. For high pressures the cushion and cover are made of asbestos instead of flax.

FIG. 6. A BRUSH AND HOLDER

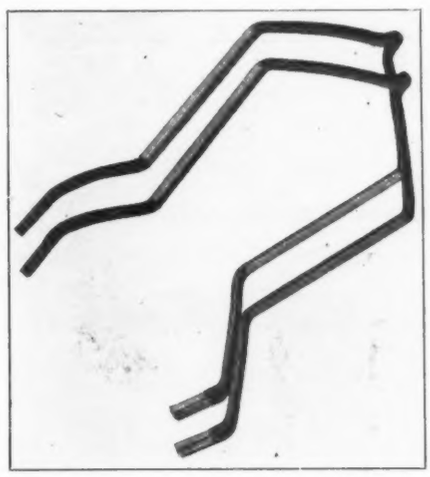
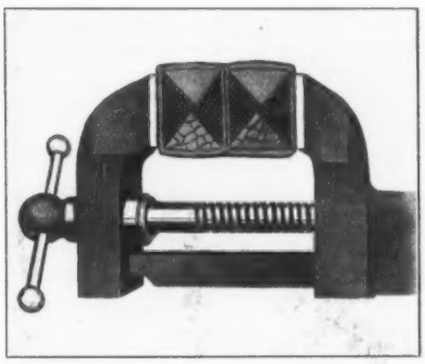


FIG. 5. COILS FOR TWO-PATH ARMATURE WINDING

CHESTERTON'S "METAL-WOVE" RING PACKING

"VAPORITE" COMPRESSED ASBESTOS SHEETING



ADVANCE "TRIO" ROD PACKING

James Watt was born in Greenock, Scotland, January 19, 1736.

Power Plant Machinery and Appliances

Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

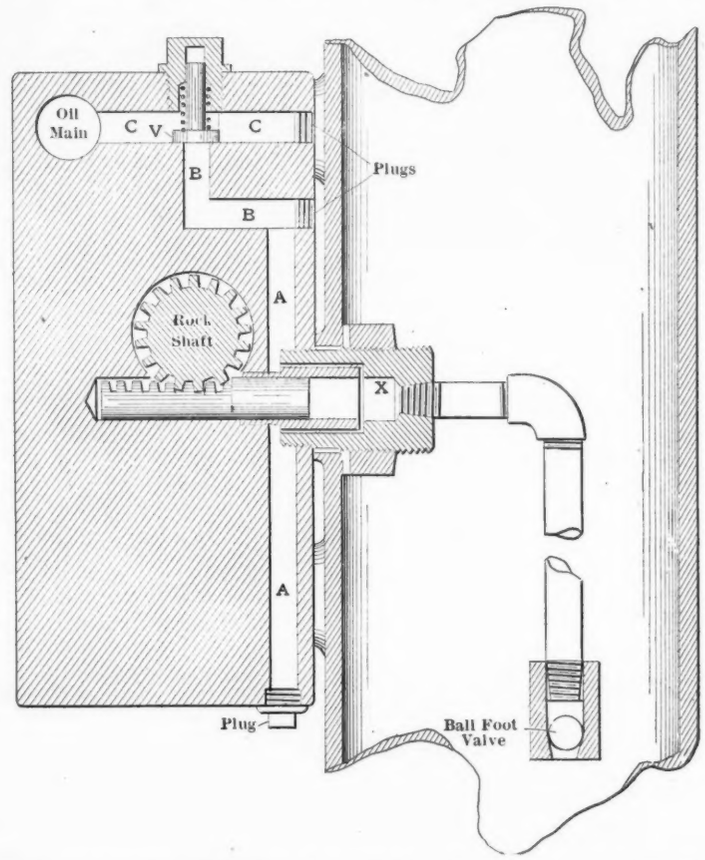
MUST BE NEW OR INTERESTING

An 18-feed Triplex Oil Pump

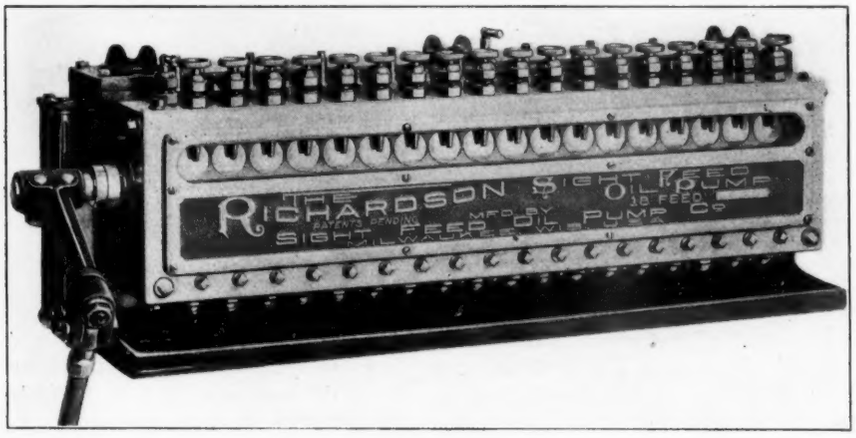
We illustrate herewith an essential feature of an unusual oil-pump outfit, one of two which were built recently by the Sight Feed Oil Pump Company, of Milwaukee, for the lubrication of large vertical pumping engines of the triple-expansion type. Up to a short time ago it was thought that an eight-feed oil pump was about as large as could be well made in one piece, but the pump in question has 18 individual feeds and automatically handles three kinds of oils, without intermixing. The mechanism is driven by one lever, the principle being that incorporated in the well known "Richardson" oil pumps made by the same company.

The new pump is 33½ inches long and weighs approximately 300 pounds. The oil tank is divided into three sections and there are three separate circulating plungers which take the oil out of these compartments and circulate it up to the feed-valves on each delivery line, the excess oil being returned to the tank through overflow dams, or increase-feed valves, connected with the different sight-feed pumps. Each delivery line has its individual pumping plunger and check valves, and each of the circulating pumps sends its particular kind of oil to such of these individual sight feeds as it is intended to serve. The operating lever is actuated by a steam- or air-driven motor.

The accompanying sectional view of the pump body and middle oil compartment shows how the circulating plunger for this middle section extends horizontally from the back of the pump body and connects with a short pipe which drops down into the oil compartment, with a ball foot-valve at the end of the pipe. The oil is drawn up through this pipe and into a chamber *X*, and when the plunger goes back it forces the oil from the chamber into the upper part of the drilled channel *A*, whence it is forced through the drilled passage *B* to the valve *V*, and is carried through another drilled passage *C* to the oil main, which leads to its series of individual feeder nozzles. In this case the middle plunger is located between the sixth and seventh feeds from the right end, being entirely hidden within the tank and pump body.



SHOWING CIRCULATING-PLUNGER ARRANGEMENT FOR THE MIDDLE COMPARTMENT



EIGHTEEN-FEED "TRIPLEX" OIL PUMP

The circulating plungers used in the outside or end compartments are similar to those usually placed in the left end of a "Richardson" pump. In this 18-feed pump, however, there are two—one in each end. Their action is similar to that of the plunger shown, i.e., each circulates the oil from the tank past the feed nozzles, throwing the excess back to the tank through the increase-feed valves. The pumping mechanism for each of the 18 oil lines is such as is employed in all "Richardson" oil pumps, comprising a forcing plunger, valves and overflow dam.

This is believed to be the largest posi-

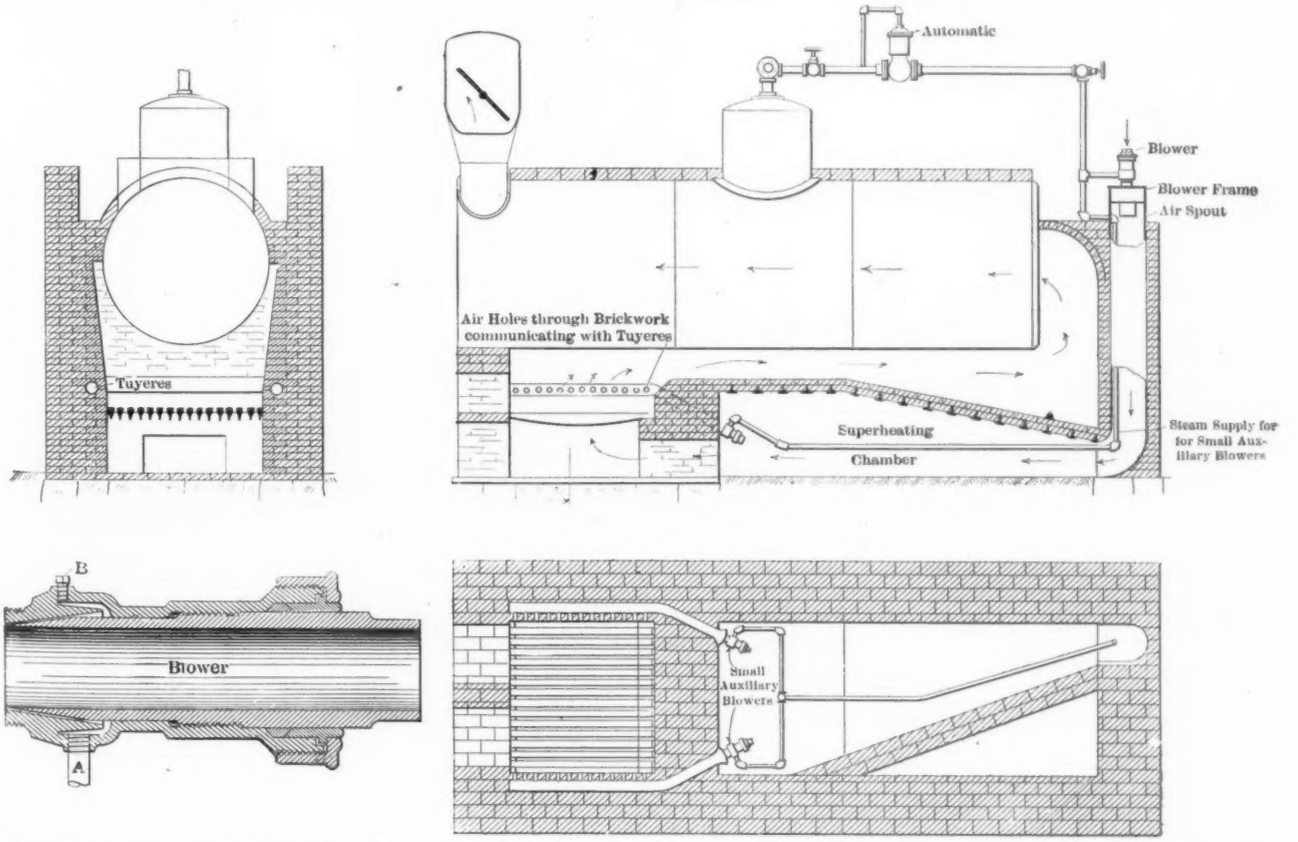
tively driven force-feed oil pump ever built. Its construction naturally involved difficulties in machining, particularly in arranging for the plunger in the back of the pump, which necessitated drilling channels in the casting, as stated. That obstacle overcome, it is evident that almost any number of different kinds of oil can be handled automatically without intermixing, by building compartments enough and drilling the necessary number of passages for the inside plungers.

The Sight Feed Oil Company has built another 18-feed pump, to go to Canada, which is intended to deliver cylinder oil, engine oil and air-compressor oil, all the feeds being automatic in their action.

The Heinrich Furnace

The Heinrich furnace, or system of combustion, consists of an arrangement by which an automatic valve opens when the pressure in a battery of boilers falls below a predetermined point and admits steam to a series of blowers, with one of which each boiler is equipped, as shown by the accompanying engraving. An enlarged section of this blower in the lower left-hand corner shows that steam is admitted through the pipe *A* and passes out through the conical opening, which is adjustable by unscrewing the tube entraining air with it through the central pipe, and through the passages at the outside of the pipe when this blower is mounted in a frame, as shown in the other view. The bolt at *B* is simply for cleaning-out purposes.

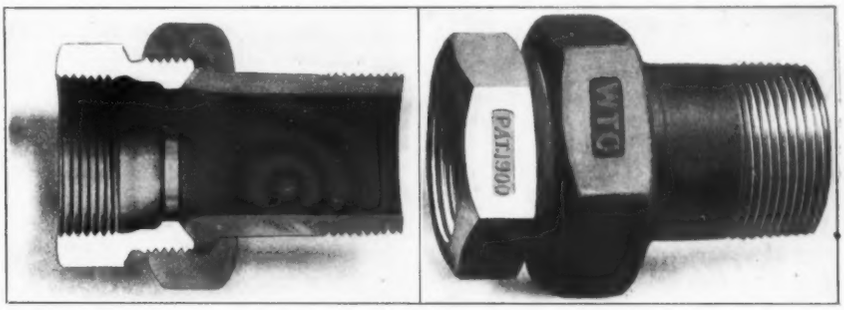
This blower takes air from the top of the boilers, forces it through the superheating chamber, whence it passes through a passage in the bridgewall to the closed ash-pit and through the fire-bed. Two auxiliary blowers force the heated air into tuyeres in the side walls, where it is discharged across the fire. The starting up of the blowers is a signal to the fireman to coal up, and, as the firing takes place while the heated air is being furnished under pressure, an abundance of oxygen is supplied to the gases distilled out from the freshly fired fuel, securing their combustion and avoiding the production of smoke. The jets being in use but a small proportion of the time, it is claimed that they will use less than 1 per cent. of the total amount of steam generated. The system is being introduced by the Heinrich Manufacturing Company, of Milwaukee, Wis.



SECTIONAL ELEVATIONS OF HEINRICH FURNACE, PLAN SHOWING SUPERHEATING AIR CHAMBER, TUYERE CONNECTIONS AND ENLARGED SECTION OF BLOWER

"Kewanee" Male and Female Union

The "Kewanee" male and female union is designed for use in cases which have ordinarily called for a female union and a nipple, but as connection is made direct with the male end of the "Kewanee" union the nipple is not needed; hence it is especially suitable for close work. By reference to the illustration it will be seen that the "Kewanee" comprises three parts only, and is very strong. It has a brass to iron connection between the ring and the female end, which prevents the parts being rusted together, and a ball-joint seat which obviates the use of a gasket and

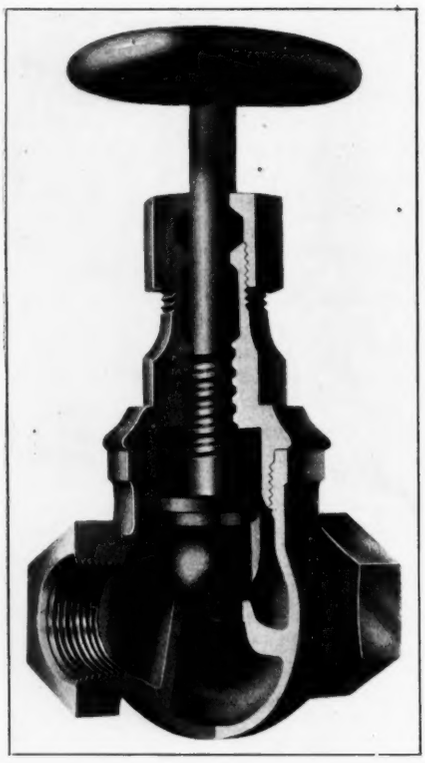


"KEWANEE" MALE AND FEMALE UNION

insures a tight joint. The thread or brass part has an hexagonal end and can be easily manipulated with an ordinary monkey wrench. Each union is subjected to a rigid test under water with compressed air. It is the product of the Western Tube Company, of Kewanee, Ill.

The Farrell-Lyman Ball-disk Valve

Accompanying is a sectional view of the Farrell-Lyman ball-disk valve, the characteristic of which is the employment of a perfectly spherical hard brass ball in place of the usual form of valve disk. As will be noted, the ball is held in place by the prongs of a cage, yet loosely so, being left free to turn with every movement of the valve stem, so the ball will change its position of contact with the seat, whether there is pressure on the line or not. It is



FARRELL-LYMAN BALL-DISK VALVE

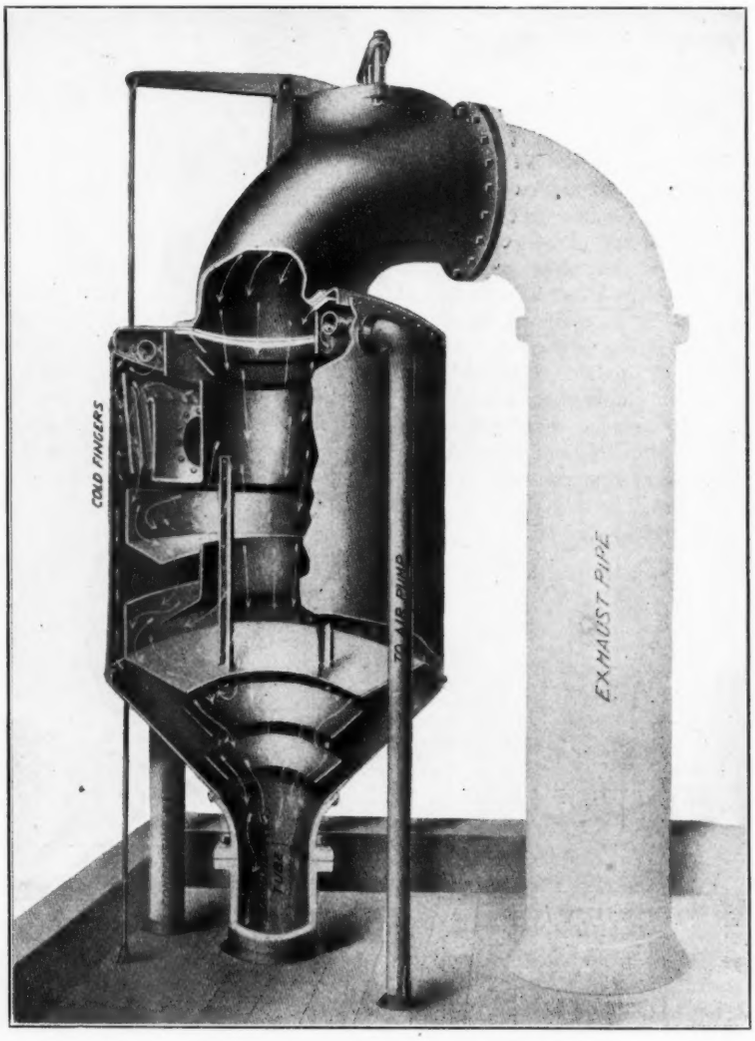
further pointed out that the use of a ball instead of a flat disk reduces to a minimum the tendency to wire-draw and that the peculiar whirling action of the ball throws dirt or chips away from the seat, thereby eliminating liability to cut or pit the seat. Furthermore, the ball is much harder than the seat, making it practical to use a narrow seat, which is easier to keep tight than a wide one.

The valve is particularly designed for a large area of inlet and outlet and has full opening through the seat. It is packed with high-grade metallic packing, and is considered equally suitable for steam, water, air, gas or oil. The parts are made of the highest grade of steam metal, and each valve is tested to 500 pounds cold-water pressure before leaving the factory. The valve is made by the Lyman Manufacturing Company, Erie and Terrace streets, Buffalo, N. Y.

The Heisler Barometric Condenser

Reference to the accompanying engraving will show the capaciousness of the Heisler barometric condenser, especially the large inlet and outlet orifices, and the large air-separating or cooling chamber which is provided above the colder water surfaces. The air in its final passage to this cooling chamber comes in contact with the "cold-finger" belt shown, but does not touch the water, to absorb moisture; therefore, the air should be perfectly dry and cool before it leaves the condenser.

The spill trays have been so designed and located, with abundant room overhead, that when a quantity of water largely in excess of the maximum capacity is drawn or pumped into the condenser, to meet an emergency, the apparatus will not become flooded, but will afford 50 per cent. direct-current spraying surface. It has also been the purpose to do away with conditions which would require an additional barometric tube, and any automatic device for breaking abnormal reverse currents of vapor and water due to a sudden inrush of steam. The form of the mouth or throat opening into the barometric tube is such that it augments the velocity of the condensing water when discharging from the condensing chamber down to the hot-well. Suction gills collect the steam and air so they may be drawn down into the discharge tube by the velocity of the water entering at the contracted orifice above the gills. As may be conceived, there is slight if any possibility of the condenser becoming clogged.



THE HEISLER BAROMETRIC CONDENSER

In operation, the exhaust steam enters the condensing chamber centrally from above and in its rapid downward passage it impinges first against the hottest water at the instant the water enters the air gills located directly above the mouth of the barometric or discharge tube. The cold condensing water enters the annular trough shown above the

series of circular spill trays, and flows out of the trays in a cylindrical cataract. Intervening between the cylindrical cataract and the outer walls of the large condensing chamber is a large annular passage which permits the gradual upward flow of uncondensable vapors and air, which precipitate moisture as they slowly rise and come in contact with the colder water, and finally with the belt of cold fingers, or baffle plates, referred to. As the air rises above the cold fingers it is collected by a suitable dry pipe, or trap, and is carried to a dry vacuum pipe.

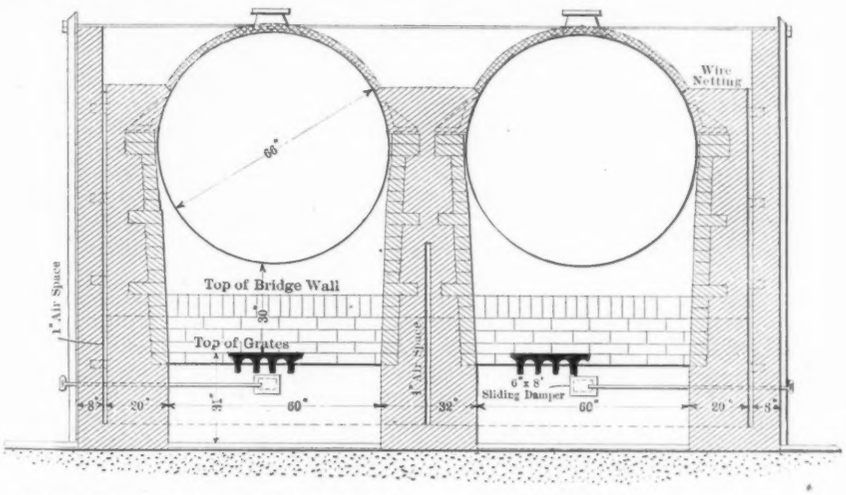
Directly under the exhaust inlet is a nest of circulating gills which cause a continual circulation of vapor currents through the chamber, the object being to materially increase the condensing capacity, somewhat as in a cooling tower. The air gills at the mouth of the discharge tube assist in discharging air from the condensing chamber.

These condensers are made by the Heisler Manufacturing Company, St. Marys, O.

The Improved Bernhard Boiler Setting

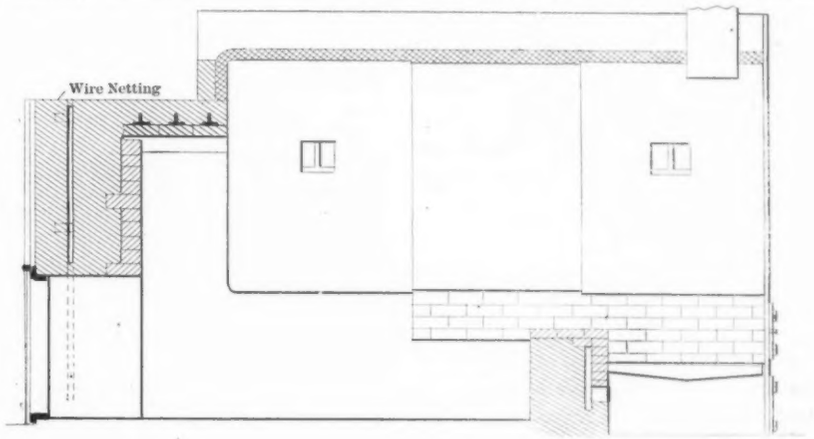
This setting, since its description in POWER some eight years ago, has undergone the development shown in the accompanying engravings. It will be remembered that the principal feature of the setting was that the boiler and the walls in immediate contact with it were set independently of the main or outside wall, with air spaces through which air was allowed to circulate sufficiently to keep the temperature of the outside wall normal and prevent cracking. It was inevitable that Mr. Bernhard should see the wisdom of connecting these interior spaces with the ash pit, so that the cool air drawn into them at the top, and gathering the heat absorbed by the walls, should return it to the furnace instead of allowing it to accumulate in the walls to their detriment, or to be carried into the room.

The drawings show plainly the passages allowed for this purpose in the side walls, connecting to the similar space behind the fire-brick facing of the bridgewall, and discharging into the ash pit through the rectangular opening in the center. This rectangular opening is protected by a sliding door or damper, which may be closed while ashes are being handled, preventing the liability of dust and ashes being drawn in to clog the passages. When the ash-pit doors are closed, the flow of air is outward into the ash pit, due to the draft, and there is no such tendency. The wire netting with which the non-connecting material which covers the boiler is supported is somewhat differently arranged, especially with regard to the back arch. It extends down the sides to the point at which the wall is drawn in to the boiler and may be withdrawn to allow of the examination of the side seams and replaced at small expense.



TRANSVERSE SECTION THROUGH FURNACE OF BERNHARD SETTING FOR TWO BOILERS

The interior wall, although independent of the exterior, is tied into it by headers projecting into pockets, as shown in the engraving, the allowances being made so that while there is ample movement for compensation for temperature changes, the structure derives a stability due to the combined thickness of the walls. Mr. Bernhard now devotes his entire attention to setting boilers upon this system, and is located at 184 Summer street, Boston, Mass.



L. BERNHARD BOILER SETTING

The "Minerva" Wire Brush

Fig. 1 herewith shows the details of construction of the "Minerva" wire brush, in the form in which it is made for cleaning boiler tubes and flues. As will be seen, each wire is bent in the shape of a hairpin. In assembling the brush the loop ends of these bent wires are inserted through large holes in the body of the brush and are kept from dropping out by means of wires threaded through the loops. Instead of being firmly embedded in the back, the wire bristles are free to recede somewhat into the cavity

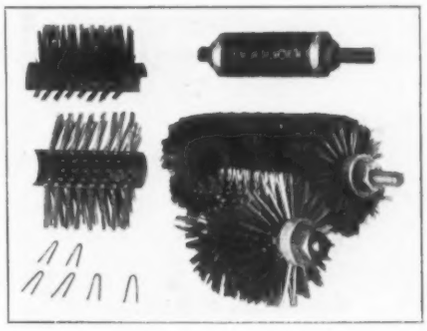


FIG. 1. DETAILS OF MINERVA WIRE BRUSH

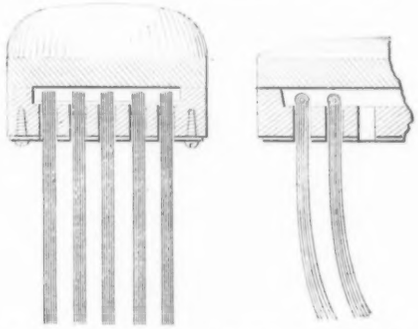


FIG. 2. END AND SIDE SECTIONS OF MINERVA WIRE BRUSH

in the brush body, thus enabling the brush to conform to the contour of the surface to be brushed. The holes are sufficiently large to permit the bristles to move freely laterally, also. In effect, this construction forms an elastic back in which there are no inactive wires and rigidity is eliminated, which obviates the likelihood of the wires breaking off close to the shoulder, as when the wire bends around a fixed point. The same principles are applied in making up the floor brush shown in section in Fig. 2.

They are made in a variety of forms, including flue brushes, boiler-tube brushes, brushes for cleaning castings, concrete floors, building fronts and sidewalks, by the American Wire Brush Company, 25 Broad street, New York City. For Ohio, West Virginia and Pennsylvania (outside of Philadelphia), the business is managed by the Minerva Wire Brush Company, 2 Ross street, Pittsburg, Penn.

Rider Ammonia Compressor

The Rider ammonia compressor for either wet or dry compression, which is illustrated herewith, is designed upon Kent's theory that in order to obtain the best results it is absolutely necessary to fill the cylinder as *full* as possible with gas as *cold* as possible, "since every degree of expansion here means work to be performed a second time without useful result." To attain this object the cold end of the compressor is surrounded by cold ammonia gas in circulation.

The inlet valve, the area of which is equal to about 25 per cent. of the area of the cylinder, is operated mechanically by the direct motion of the piston-rod, and is fully opened at the end of the stroke. The gas enters at or near zero, and the heat of compression begins to develop as the gas is compressed, but this heat does not reach its maximum until near the termination of the stroke.

At the moment of final compression the cylinder head serves as a water jacket, it being deemed that this is all the jacketing necessary if a full charge of cold gas has been taken into the cylinder. The inlet valve opens outward, precluding the possibility of its getting into the cylinder by accident; it is without springs, but is cushioned on gas to prevent shock.

The outlet valve is located in the bottom of the cylinder to allow drainage of any liquid that might enter during the dry-compression process, or if the machine should be used as a wet compressor, the drainage valve obviates the likelihood of liquid ammonia re-evaporating in the clearance spaces. Also, liquid which may have come over in the suction is discharged ahead of the gas, and none is left in the cylinder to re-expand.

The stuffing-box for the piston-rod is on the low-pressure side, and is, therefore, easy to pack. The rod is lubricated by a simple oil cup. Excess oil is caught and drained off. The cylinder is oiled as in air-compressor practice, just enough oil being introduced to coat the walls.

The stroke of these compressors is long, about three diameters, to insure minimum percentage of clearance. The compressors are self-contained, to facilitate erection and minimize foundation. Corliss valves with adjustable cut-off are used, even in the small sizes, the speed being regulated by a throttling governor only on engines under 12 inches diameter.

Patents are pending on this apparatus, which is the invention of F. A. Rider, of Pittsburg, Penn.

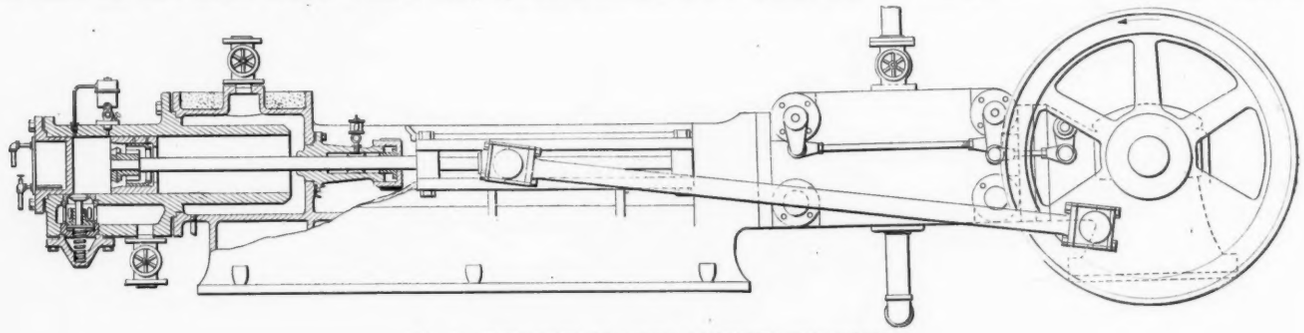


FIG. 1. ELEVATION OF RIDER AMMONIA COMPRESSOR

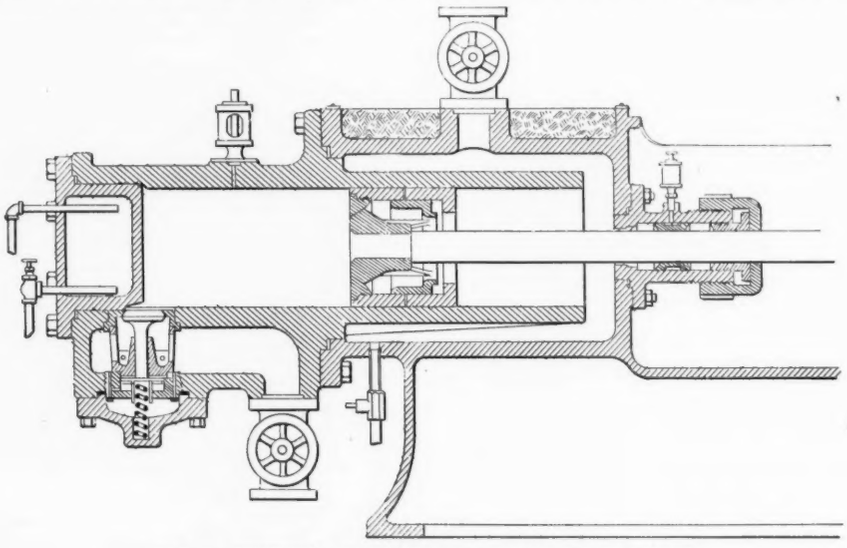
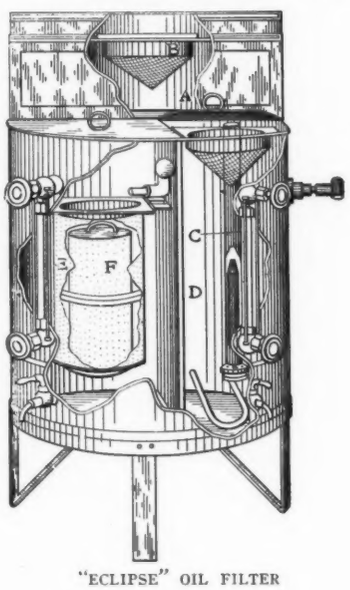


FIG. 2. SECTIONAL ELEVATION OF CYLINDER AND VALVES

"Eclipse" Oil Filter

Herewith is a sectional view which shows the construction of the "Eclipse" oil filter, a new waste-oil purifying apparatus which has just been marketed by the Standard Gauge Manufacturing Company, of Syracuse, N. Y. The salient features of this filter comprise a large auxiliary reservoir, which holds a quantity of oil equal to about one-third the capacity of the filter, and which acts as a storage



"ECLIPSE" OIL FILTER

tank upon occasion; an automatic shut-off float which prevents dirty oil overflowing into the clean-oil chamber, and cloth filtering surfaces of double cylinders through which the oil filters both in and out.

The *modus operandi* of the new filter is as follows: Waste oil is poured into the auxiliary reservoir *A* through the conical sieve *B*, whence it passes down through a funnel *C*, and out through ports in the bottom into the water chamber *D*. The oil spreads out fanwise into a thin layer as it flows from the openings in the bottom of *C*, permitting heavy impurities to precipitate. The oil then rises through warm water in the chamber *D*, which process tends to wash it and further release impurities, and it then passes through the filtering walls of the cylinders *E* and *F*, which completes the process and the clean oil may be drawn off at the bottom as required. These filters are made in six sizes.

Chimney Accidents

Within a few days of each other came reports of accidents to three types of chimneys. The first was an ordinary brick chimney, at Millville, N. J., which suddenly toppled over, killing three girl employees in the factory where it occurred and injuring a number of others. An occasional test of the plumbness of a shaft would seem to be an advisable precaution that would probably lead to the tearing down of a number of shafts, if they are as far out of plumb as they appear.

On the first day of April, while the wind was blowing a gale, the upper twenty-five feet of a self-supporting steel stack, 125 feet high, serving the power plant of the Hotel Chamberlin, at Old Point Comfort, Va., blew off. This stack was built in 1897, when additional boiler capacity was put in. The plates, which were ⅜-inch at the bottom, were reduced to less than ¼-inch at the top. The latter section had become so thin by internal corrosion that, under the heavy wind pressure, it fell apart, the rivets pulling through.

A mass of unset concrete fell from the top of a chimney which was being erected at the gas plant of the Public Service Corporation, at Hampton, Va., carrying down two workmen with it, killing both. The structure had reached a hight of some seventy feet, and it is surmised that the workmen prematurely removed the quoins from the forms, thinking that the cement had set. A similar accident had happened at Baltimore a few days before, unattended by fatalities.

In the case of the concrete chimneys the failures were construction accidents, simply. This form of chimney once completed, and of proper material properly mixed, is very substantial—practically a monolith—but these accidents demonstrate that a knowledge of the material and care in its handling are essential to the safe progress of the work, as well as to the integrity of the structure.

Charles H. Haswell

Charles Haynes Haswell, the oldest engineer in the world, and dean of the civil-engineering profession, died at his home in New York City, Sunday evening, May 12, as the result of shock attending the dislocation of a shoulder, occasioned a few days before by slipping and falling on his dining-room floor. He was born in New York, May 22, 1809, and was therefore within a few days of 98 years of age. Mr. Haswell had always been in good health and regularly practised his profession, and up to the time of his death, in addition to superintending the construction of city works at Riker's island, was serving as consulting engineer to the New York City Board of Apportionment.

THE LATE CHARLES H. HASWELL

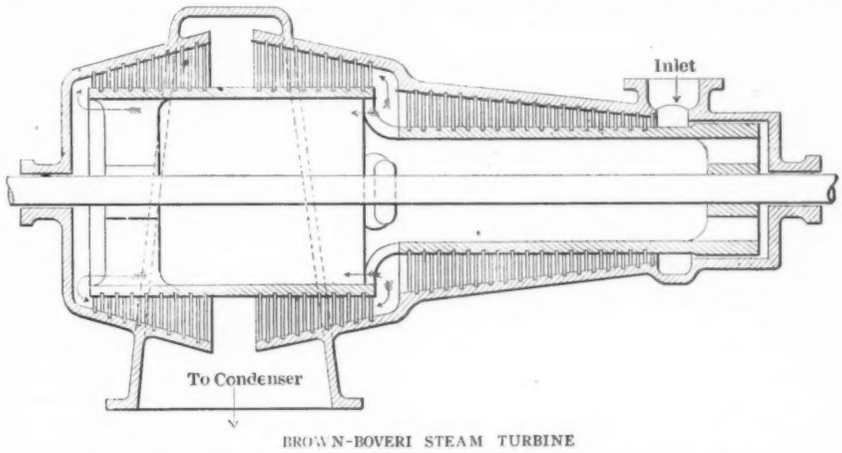
In 1829 Mr. Haswell went to work in the boiler shop of James P. Allaire, at Lakewood, N. J., and in 1836 received an appointment as United States naval engineer. In 1845 he received the title of "engineer-in-chief" of the United States Navy, being first to attain this rank. He designed all the machinery for ten naval vessels, introducing several mechanical improvements which tended to promote higher efficiency of the early steam navy. During this period, in 1837, he built the first steam yacht, aside from those built by Fulton and other early experimenters, ever launched.

Following his retirement from the navy, Mr. Haswell engaged in engineering practice in New York. He was surveyor of steamships for the New York marine underwriters for more than forty years. He designed and located the city buildings on Hoffman's island and also built the crib bulkhead at Hart's island.

Mr. Haswell was the author of "Haswell's Pocket-book," which has run through 60 editions, and of "Reminiscences of an Octogenarian." He was a member of the American Society of Civil Engineers, as well as a member of and frequent visitor at the Engineering Club. The accompanying photograph was the last one taken of him and shows him to have possessed remarkable vitality.

Double-flow Steam Turbine

The accompanying engraving shows how the Swiss firm of Brown, Boveri & Co. has to an extent realized the advantages of a double-flow turbine, while retaining the full size of the initial blade, and thus the small proportion of clearance to total area. Steam enters at the right and passes through the first stage in an obvious manner, discharging through the drum carrying the low-pressure blades, as well as directly into one of the two sections into which these blades are divided. It is necessary to balance only the high-pressure stage, and any steam passing the balancing disks is passed through the center of the drum and joins that which was in the low-pressure stage.



BROWN-BOVERI STEAM TURBINE

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

To Calculate Cylinder Diameter and Size of Feed-pump

(1) The diameter of a high-pressure cylinder is 10 inches; cut-off, 0.25 of stroke; boiler pressure, 100 pounds; terminal pressure, 10 pounds. What is the diameter of the low-pressure cylinder, not allowing for cylinder clearance on the receiver drop?

(2) A boiler is 100 horse-power; steam pressure, 125 pounds. What should be the size of feed-pump at both ends

H. J. A.

(1) Supposing the given pressures to be absolute, i.e., that the gage pressure at the commencement of the stroke is 85.3, giving an absolute of

$$85.3 + 14.7 = 100,$$

and that the 10 pounds terminal is also absolute, and that the mode of expansion is such that the product of the volumes and pressures remains constant, which is approximately true for the steam engine without jackets or superheat, then the steam would have to be expanded to ten times its original volume to reduce its pressure to one-tenth of the initial.

Since the cut-off is 0.25, or one-quarter, of the stroke, the steam is expanded to four times its initial volume in the high-pressure cylinder; and as the total number of expansions is the product of those in each cylinder, there are left:

$$10 \div 4 = 2.5$$

to be completed in the low-, i.e., the volume of the low-pressure cylinder must be 2.5 times that of the high-. As the strokes are the same, the cross-sectional area must be 2.5 times that of the high-pressure.

The area of the high-pressure cylinder is:

$$10 \times 10 \times 0.7854 = 78.54 \text{ square inches.}$$

The area of the low-pressure should be:

$$78.54 \times 2.5 = 196.35 \text{ square inches,}$$

the diameter corresponding with which is:

$$D = \frac{196.35}{\sqrt{0.7854}} = \sqrt{250} = 15.8 \text{ inches.}$$

This could be got at more directly by saying at once that, as the areas of circles increase as the squares of their diameters, a circle to be be 2.5 times the area of another must be $\sqrt{2.5}$ times the diameter, and

$$10 \times \sqrt{2.5} = 15.8.$$

(2) A boiler needs, in round numbers, 30 pounds of water per horse-power and must be able to develop one-third more than its rated capacity, or to evaporate 40 pounds per hour per horse-power. Since the pump must be able to supply water faster than the boiler evaporates it, to catch up a lower water line, etc., let us say that it should supply at least 45 pounds of water per hour per horse-power. This is:

$$\frac{45}{60} \times \frac{1728}{62} = 21 \text{ cubic inches}$$

per minute per horse-power.

Your 100-horse-power boiler will then require:

$$100 \times 21 = 2100 \text{ cubic inches}$$

per minute, or, say, at 100 strokes per minute, 21 cubic inches per stroke. With a 4-inch stroke the area would have to be:

$$21 \div 4 = 5.25 \text{ square inches,}$$

the diameter corresponding to which would be:

$$\frac{5.25}{\sqrt{0.7854}} = 2.59 \text{ inches.}$$

The nearest adequate commercial size is 2¾, and a 4½-inch steam cylinder is usually used with this diameter of water cylinder, so that the pump would be:

4½x2¾x4-inch.

Saturated and Superheated Steam

(1) If steam in a boiler rises from low to high pressure simply by the addition of heat, why does not the addition of superheat to the steam in pipes connected directly to the boiler raise the pressure?

(2) What is saturated steam saturated with, water, watery vapor or heat?

D. H.

(1) It does.

(2) Heat.

Place a pound of water over a source of heat. If the pressure upon it is that of the atmosphere at sea level, 14.7 pounds, it will commence to boil when its temperature attains 212 degrees. If the steam is allowed to escape as it forms, so that the pressure does not rise above that of the atmosphere, the temperature will not rise above 212 degrees. If the vessel containing the water is closed, so that the steam cannot escape, the pressure will rise, and with it the temperature of the water, each pressure having a corresponding boiling point. So long as there is any water present, the pressure will be that corresponding with the temperature, as found in a table of the properties of saturated steam.

If the process is conducted at constant pressure, the water will not boil until it gets to the corresponding temperature, and will not rise above that temperature, no matter how much heat is applied. If the pressure is allowed to increase as the steam is made and accumulated, the temperature will go up with it. In either case there will arrive an instant when the last trace of water or moisture passes into steam, at which time there will have been absorbed by the pound of water a certain number of units of heat (which number will be found in the column of total heat in the table of properties of saturated steam) and would be known as "dry saturated steam," having all the heat that it can carry under these conditions. If the application of heat be continued, the temperature of the steam will rise above that due to its pressure. It may be heated now just like air or any other gas, and its pressure will depend upon its volume and temperature. If it gets a chance to expand as it is heated, the pressure will not increase; if the volume is kept constant or is not increased as fast as the steam wants to expand, the pressure will increase.

Contents of a Coal Pile

I have a pile of coal, triangular in shape, and would like to know how many tons there are in the pile. The hight is 17 feet, width 28 feet and length 88 feet. How many cubic feet are there in a ton of coal, and how is it figured?

W. A. D.

The area of a triangle is half the product of its width and hight. Your coal pile would therefore contain $28 \times 17 \times 88 \div 2$ cubic feet. It will make some difference what the kind and size of the coal is as to its weight per cubic foot. According to measurements made with Wilkes-Barre anthracite, it requires 32.2 feet of lump, 33.9 cubic feet of broken, 34.5 cubic feet of egg, 34.8 cubic feet of stove, 35.7 cubic feet of chestnut and 36.7 cubic feet of pea coal to make one ton of 2240 pounds.

The proportional figures for the short ton are: 28.8 for lump, 30.3 for broken, 30.8 for egg, 31.1 for stove, 31.9 for chestnut and 32.8 for pea. If it is taken at 33 cubic feet per ton the pile will contain:

$$\frac{28 \times 17 \times 88}{2 \times 33} = 635 \text{ short tons.}$$

Motoring by a Dynamo

What is "motoring" by a dynamo, and what causes it? J. S. V.

Being driven as a motor by current from some other source, usually the line to which the dynamo normally delivers current. It may be caused by any condition that reduces the electromotive force of the dynamo greatly below that of a circuit to which other dynamos are also connected. When this occurs, current flows from the circuit to the affected dynamo and drives it as a motor. Ordinarily, a reduction of the dynamo's e.m.f. to as little as 1 per cent. below the voltage of the circuit which it is supplying will produce motoring; that is, if the actual circuit voltage be 250 and the speed or field excitation of the dynamo be reduced until it generates 247½ volts, it will be driven as a motor by the current supplied from the other machines connected to the same circuit. In many cases even a smaller reduction in dynamo voltage will produce motoring.

Book Reviews

A Manual of Hydraulics. By R. Busquet. Translated by A. H. Peake, F. A. Longmans, Green & Co., New York and London. Cloth, 312 pages, 5x7; illustrated. Price, $2.10.

The increasing price of coal consequent upon its growing consumption offsets all the economies attained by successive improvements in the efficiency of heat engines, and gives increased importance to the value of the water powers made available by the development of electrical transmission. This book has been written to meet the demands for a simple presentation of the problems attending the development of water powers, and in the installation of hydraulic plants. The book is not, however, a purely descriptive work, designed merely for popular use, nor is it an abstruse treatise suitable only for engineers versed in the higher mathematics. It is a text-book of applied hydraulics, in which complete technical theories and all useful calculations for the erection of hydraulic plants are presented. In its translation, the simple arithmetical methods used in the original have been adhered to, so that only an elementary knowledge of arithmetic and geometry is necessary to follow the numerous examples given. All dimensions have been changed into British units, and the constants in the various formulas have been correspondingly modified. The author is professor at l'Ecole Industrielle, of Lyons, and the translator demonstrator in mechanism and applied mechanics in the University of Cambridge. It is an excellent book for the practical man, who wishes to be informed in the fundamentals of the subject.

Alternating-current Motors. By A. S. McAllister. Published by McGraw Publishing Company, New York. Cloth; 286 pages, 6x9 inches; 122 illustrations. Price, $3.50.

This is about the cleanest-cut presentation of the principles underlying the design and operation of alternating-current motors that has ever come to the reviewer's notice. The book is essentially a text-book and will not be intelligible to anyone who cannot follow algebraic and trigonometrical exposition and the usual graphical treatment of alternating-current problems. To those, however, who are familiar with the simpler processes of the mathematical branches mentioned the book should be most welcome. The author's style is direct, clear and forceful, and his mastery of the subject impresses the reader more and more strongly as successive chapters are read. As the title of the book indicates, its scope covers all forms of alternating-current motor.

A Text-book on Hydraulics. By L. M. Hoskins. Published by Henry Holt & Co., New York. Cloth; 271 pages, including appendices, 6x9 inches; illustrated by figures, diagrams and tables. Price $2.50.

This is an excellent work for students who are well grounded in mechanics and mathematics. A commendable feature is the absence of entangling data, especially in table form, which are so apt to be taken for precise knowledge, without verification, or which are seldom applicable to the case in hand. The work combines theory and practice in a practical way, so to speak. Bernoulli's theorem, or the general equation of energy, as the author has it, is the basic principle of the discussions and problems which treat of the steady flow of liquids. Turbines and water wheels are theoretically treated in outline, but several illustrations are given showing typical American practice. There are three appendices, treating of the Steady Flow of a Gas, Relative Motion, and Conversion Factors.

Electrical Wiring and Construction Tables. By H. C. Horstmann and V. H. Tousley. Published by F. J. Drake & Co., Chicago, Ill. Soft leather; 115 pages, 4x6 inches; numerous tables and charts. Price, $1.50.

This is one of the many publications intended to lighten the work of those who have to deal with the layout of electric light and power wiring. In some respects it is very useful; in others it falls far short of what a book of its class should be. The tables and charts for the selection of wire sizes with regard to the drop are more troublesome to apply than the formulas on which they are based. The charts are deficient in that no scale of volts is given and the tables involve a tedious correction process that is more complex and liable to cause error than the ordinary "drop" formula. The data relating to Cooper-Hewitt lamps, tables of wire capacities in terms of filament and Nernst lamps, and the section on the Chicago rules are good, and of much practical value; aside from these, however, the book is rather disappointing.

Machine Design. By Charles H. Benjamin. Published by Henry Holt & Co., New York. Cloth; 202 pages, 5x7½ inches; 84 illustrations and 34 tables.

There are twelve chapters in this work, treating of Units and Tables, Frame Design, Cylinders and Pipes, Fastenings, Springs, Sliding Bearings, Journals, Pivots and Bearings, Ball and Roller Bearings, Shafting, Couplings and Hangers, Gears, Pulleys and Cranks, Fly-wheels, Transmission by Belts and Ropes. The author, professor of mechanical engineering in the Case School of Applied Science, states that this work embodies to a considerable extent his experience in teaching and commercial work, and his practice as an engineer. A very instructive feature of the work lies in the large experimental work with which Professor Benjamin's name is permanently connected, noticeably that upon cast-iron cylinders, pipe fittings, helical springs, roller bearings, gear teeth, pulley arms and the bursting strength of fly-wheels. The author has appended practical problems to the more important chapters, and in addition, the numerous tables of values and dimensions, as well as the clearly stated formulas for the strength and stiffness of machine details, render the work useful both as a text-book and a hand-book.

Heat and Light from Municipal and Other Waste. By Joseph G. Branch. Published by Wm. H. O'Brien Printing and Publishing Company, St. Louis, Mo. Cloth; 305 pages, 5½x8 inches; 56 illustrations and 30 tables. Price, $3.

This work, which is largely a compilation, was written for municipalities and engineers. It treats of public waste in the form of refuse and private waste of exhaust steam from power plants. Incidentally, the author is of opinion that exhaust steam should be sold to central heating plants and thereby become a source of profit. Of especial interest are the reports on the method of refuse disposal in seventy-four American cities; likewise descriptions of the leading types of American incinerators. A chapter is devoted to British and foreign destructors and incinerators, together with official data showing cost and the power purposes for which waste heat from incinerated refuse is utilized. Specifications for a complete heating plant, also form of contract for supplying exhaust steam for heating, may be studied with profit. Altogether, the subject is handled in a most readable and apparently authentic fashion.

A Study in Graphite. By Prof. W. F. M. Goss, Purdue University. Published by the Joseph Dixon Crucible Company, Jersey City, N. J. Paper, 6x9 inches, 43 pages, illustrated. Price, 25 cents.

This pamphlet is based upon experiments made under the direction of Professor Goss at Purdue University, to demonstrate the value of graphite as a lubricant. For precise measurements of the coefficient of friction there was especially constructed for this work a pendulum testing machine of sufficient size to receive a standard axle journal and box such as are usually employed under 60,000-pound freight cars, and the pamphlet illustrates and describes the machine, recounts the tests carried out with it, considers the use of graphite alone, combined with oil and grease, and when combined mechanically with the metal of a journal box. Half-tone engravings represent accurately the conditions of the surfaces as affected by the tests.

THE SEVEN FOLLIES OF SCIENCE. By John Phin. Published by D. Van Nostrand Company, New York. Cloth; 178 pages, 5¼x7⅞ inches; with numerous illustrations. Price $1.25 net.

Here are our old friends bobbing up again in new and mighty attractive dress, and with a goodly company in their train. It is just what we have been waiting for—the exposition in language that everybody can understand of certain problems and paradoxes that have not only spasmodically occupied our attention almost since our earliest recollection, but have likewise puzzled our forebears away back to the beginning of civilization. Of course, we know that it is as impossible to "square the circle" as for "a man to lift himself by the straps of his boots," and that "perpetual motion" is just as elusive as the "elixir of life." Equally of course, many learned individuals have told us all about it, piece by piece, in language too dense for our limited understanding, but no one whom we can recall has explained it all as succinctly and entertainingly as Mr. Phin, at the same time divesting it of ultra scientific phrases and perplexing mathematical formulas. The author has appended four additional "follies" to the seven which form the basis of the work, and has supplemented these with explanations of what he calls "a small budget of paradoxes, illusions and marvels," concluding with some "curious arithmetical problems." Some of the marvels described, although old, are not generally known.

The National Electric Light Convention

The thirtieth convention of the National Electric Light Association will be held at Washington, D. C., June 4 to 7, inclusive. Several papers of special interest to POWER readers are promised and we hope to present abstracts of these in an early number.

National Export Association

The National Export Association of American Manufacturers, with offices in the Park Row building, New York City, has been organized for the purpose of furthering American export interests. One of the projects is to encourage and aid each manufacturer to open an office of his own on centrally located European soil, to serve as a base for his export operations. William A. Harris, of the William A. Harris Steam Engine Company, is president of the new association. The secretary is R. Wohlfarth.

Burning Ashes

(*Continued from page 385.*)

Into each ton of this mixture were worked

10 pounds of common salt (NaCl)
¼ pound of oxalic acid,

by the use of 40 gallons of water. Considering everything, this "ash-fuel" mixture cost 85 cents per ton.

The fuels contained, as shown by the bomb calorimeter,

14,025 B.t.u. per pound of dry Reynoldsville coal.
14,705 B.t.u. per pound of "ash-fuel" mixture.

REASONS WHY THE "ASH-FUEL" MIXTURE PRODUCES A SAVING

When you first directed me to conduct these tests I believed that the "ash-fuel" mixture was a "fake," and that it was a waste of time to investigate it. Since, however, a fuel saving of over 80 per cent. in the cost of operating your plant results by the use of "ash-fuel" some reason therefor obtains, and I have come to the following conclusions regarding this problem:

1. To say that the results claimed for "ash-fuel" are absurd, without a careful investigation and experimentation, denotes prejudice. Such prejudice would stifle all progress.

2. We have only recently found that that Gibraltar of science—the principle of the conservation of energy—is tottering because of the discovery of radium and its properties.

3. We are accustomed to look at combustion from a single viewpoint, thinking only of the so-called "combustible" and not of its oxidation. We overlook the effects of both oxygen and its nascent ozone, although we understand them fairly well.

4. Again, we are so familiar with nitrogen as an inert and inactive part of the air that we overlook the fact that it may—under certain chemical and temperature conditions—become active, and may even be oxidized.

5. Nothing is truer than that heat results from all chemical reactions and combinations, and that combustion is an oxidation of some oxidizable material. If this is true—and it cannot be disputed—then every known substance can be burned, in that it can be oxidized, or united with oxygen, and its union or combination produces heat. We know that some substances, like silica, are not ordinarily attacked by oxygen and oxidized. But, produce the right conditions as to proportions and temperature and every substance is affected by and united with oxygen, i.e., will burn, and in burning will give off heat.

Thus far I have discussed only well-known truths, and have called attention to well-known (though not always thought of) facts, properties and principles.

Now let us apply these facts and principles to the "ash-fuel" problem.

1. The coal of the "ash-fuel" mixture is an acknowledged combustible material.

2. The ash which was used contained a little coal, say 5 per cent. of its weight.

3. Oxygen is present, with nitrogen, in the air drawn through the furnace by the chimney's draft.

4. Oxalic acid, salt and the silicon in the ash were there, the two former to act as a teaser or exciter upon the latter, which was a base or store-house of the actinic rays from the sun.

5. The temperature of the furnace combined with the "ash-fuel" mixture and the air to produce a condition necessary for and favorable to action, oxidation and combustion.

6. The water was present in the fuel as a binder, and contained both hydrogen and oxygen in the proportion of 1 to 8 by weight. The water was decomposed into its elements, hydrogen and oxygen, and the hydrogen was burned, giving off 62,032 heat units for each pound of it that was present.

7. The combustion of the "ash-fuel" mixture, though complex, was accompanied by the formation and combustion of acetylene and hydrocarbon gases, made by the combination of water, carbide, silicon, sodium chloride and a proper temperature and atmosphere. This is the secret of the matter, and solution of the problem, and is a reasonable explanation of this most remarkable discovery and phenomenon.

There is nothing, so far as I am able to judge, indicating that the products of combustion will be deleterious or injurious to the boiler, its setting, or the chimney. However, I have not made up my mind upon this point, since use and time alone can determine.

Respectfully submitted,
ANANIAS R. GUESSITT,
Mechanical Engineer.

Personal

C. W. E. Clarke, who for five years has been an assistant engineer for Sargent & Lundy, of Chicago, has resigned to become steam engineer in the electrical department of the New York Central lines, with headquarters at New York City.

Franz Erich Junge, whose contributions to POWER, especially on gas-engine progress, have frequently appeared during the past two years, has gone to Europe for the summer. Among other researches while abroad, Mr. Junge will make a special study of gas-engine development, interviewing leading manufacturers and inspecting noteworthy installations.

Business Items

The Locke Regulator Company, of Salem, Mass., reports 90 recent sales of its engine stops.

The Hall Manufacturing Company, maker of oil filters, has removed its New York office and salesroom from 62 Cliff street to 94 John street.

W. Gerhardi, with works at Ludenscheid, Westphalia, Germany, would like to receive catalogs of American manufacturers of power-plant equipment.

The Empire State Engineering Company, in connection with its New York City and Rome, N. Y., plants, has opened general offices at 149 Broadway, New York.

The Green Fuel Economizer Company has found it necessary to remove its Chicago office from the Monadnock block to the Old Colony building, in order to secure more room.

The B. F. Sturtevant Company, Boston, Mass., reports recent orders for three metal-to-metal joint fuel economizers; four mechanical-draft equipments, and seven generating sets.

The Sturtevant Engineering Company, of 147 Queen Victoria street, London, the European representatives of the B. F. Sturtevant Company, of Boston, Mass., has just opened a new office at 2, Rue Lebeau, Brussels.

The Cambria Steel Company, Johnstown, Penn., would like to receive the latest catalogs from manufacturers of machinery and supplies for general steel works equipment. They should be addressed to John W. Gocher, chief engineer.

P. L. Rhodes, formerly with the Pittsburg Supply Company, has been appointed sales manager of the Homestead Valve Manufacturing Company, Pittsburg, Penn. Mr. Rhodes succeeds C. B. Ault, who has resigned to enter another line of work.

The Standard Gauge Manufacturing Company, of Syracuse, N. Y., announces that it has added to its business a new department which will be devoted to the manufacture of the "Eclipse" oil fillers, "Eclipse" exhaust heads and sheet-metal specialties.

A. L. Curtis has opened an office at 3706 Spruce street, Philadelphia, Penn., as a consulting engineering technical advertising specialist. Mr. Curtis will not place advertising, but will advise with advertisers in the technical papers in regard to copy, etc.

The Robb-Mumford Boiler Company has removed its New York office from 11 Broadway to the West Street building, 90 West street, where it has secured commodious offices and is better equipped than ever before to handle the general boiler business in New York.

H. W. Canning has opened an office in Birmingham, Ala., at 601 Brown-Marx building and will represent in the southern district the Ball Engine Company, Erie, Penn., the Murphy Iron Works, Detroit, Mich., and the Whiting Foundry Equipment Company, Harvey, Ill.

The New York office of the B. F. Sturtevant Company has just been removed from 131 Liberty street to the Engineering building at 114 Liberty street, where much better facilities will be provided for conducting the rapidly increasing business of this company.

The Minneapolis Steel and Machinery Company, Minneapolis, Minn., builder of the Twin City Corliss engine, has issued a very neat brochure describing this engine in detail. It is the advance agent for the complete catalog now in preparation and will be sent to anyone interested.

The Pittsburgh Gage and Supply Company, Pittsburg, Penn., has recently installed White Star oiling systems in the engine rooms of eleven prominent concerns. This method of lubricating engine bearings is fully illustrated and described in a new catalog published by the company.

The San Francisco office of the General Electric Company is now permanently located in the Union Trust building, San Francisco. Since the fire the office has been located in the Union Savings Bank building at Oakland, large temporary warehouses having also been erected in the same city.

The second edition of the book on "Stationary Engineering," by J. G. Branch, B. S. M. E., published by the National Equipment Company, St. Louis, Mo., is ready. This edition contains 400 additional questions and answers, a chapter on the steam turbine, together with 36 additional full-page cuts and tables.

The Nelson Valve Company advises that it has secured the contract for valves for the new public library, New York city, and has also received a telegraphic order to ship, by express, a number of standard and extra heavy gate valves to the Pacific coast on which the express charges alone will amount to about $750.

William B. McVicker, eastern manager of the Dearborn Drug and Chemical Works, returned to New York, April 23, after a three month's business trip to Cuba. H. G. McConnaughy, of the Dearborn Drug and Chemical Works, is at present in Europe on business and pleasure, and is expected to return early in the summer.

The Heine Safety Boiler Company, St. Louis, Mo., reports recent sales of 88 boilers aggregating 28,390 horse-power. Four of the boilers, aggregating 900 horse-power, are for the Asano Cement Company, Tokio, Japan; 32 are for the Texas Company, Beaumont, Texas, to be installed in eight pipe-line oil pumping stations in Texas.

Charles H. Glasser, formerly mechanical engineer of the Camel Company, Chicago, has accepted a position with the American Steam Gauge and Valve Manufacturing Company, and will make his headquarters at the Chicago office. Mr. Glasser has had several years' experience in the mechanical field and has a very wide acquaintance.

After continued success with the We-Fu-Go water softening and purifying systems, the Illinois Central Railroad Company has just placed with Wm. B. Scaife & Sons Company, of Pittsburg, Penn., the eighth and ninth contracts for these systems, a 300,000 gallon per day plant for Manchester, Iowa, and a 400,000 gallon per day plant for Waterloo, Iowa.

The Minneapolis Steel and Machinery Company has opened a branch office at 262 Commerce street, Dallas, Texas, under the management of J. P. Greenwood. The large demand for Twin City Corliss engines and Muanzel producer-gas engines in this territory made it necessary to open an office in Texas, so as to take care of increasing business.

E. P. Leadbetter has been appointed manager of the Pittsburg office of the Buffalo Forge Company. For the past three years Mr. Leadbetter has been connected with the Philadelphia office of the Buffalo Forge Company and previous to that time at the factory office in Buffalo, N. Y. C. I. Dean, who until lately has been in charge of the Pittsburg district, has gone into mining operations in Mexico.

The United States Government, after two years of consideration, has just awarded to the Westinghouse companies a contract for the complete electrical equipment of the power station now being erected in connection with the new Congressional buildings in Washington, D. C. The contract calls for four 3000-horse-power Westinghouse-Parsons steam turbines and four 3000-horse-power Westinghouse generators.

Allis-Chalmers steam-turbine contracts obtained during the past month included seven units, comprising standard Allis-Chalmers steam turbines direct-coupled to Allis-Chalmers alternating-current generators. This company has also closed a contract for a vertical cross-compound Reynolds Corliss engine for the Bristol Tramways and Carriage Company, London. It has also recently booked orders for six Reliance engine sets.

The D. T. Williams Valve Company, Cincinnati, Ohio, has issued a neat booklet describing its regrinding valve, in an unusual manner; every part of the valve is shown and described in detail, a series of pictures is reproduced from photographs showing an engineer packing and repacking the gland, also showing how the engineer goes about it to regrind the valve. This is a booklet that an engineer will be interested in.

The Smooth-On Manufacturing Company, 572 Cummunipaw avenue, Jersey City, N. J., recenty issued the second edition of its No. 5 instruction book. This book tells a few of the many ways in which the different Smooth-On specialties have been used and the results obtained. It is a very interesting book and valuable to all manufacturing concerns, especially users of steam. The book will be sent free to anyone sending name and business address.

At the annual meeting of the stockholders of the Joseph Dixon Crucible Company the old board, consisting of Edward F. C. Young, John A. Walker, Edward L. Young, William Murray, George T. Smith, Joseph D. Bedle and George E. Long, was unanimously re-elected. The board of directors re-elected the former officers: E. F. C. Young, president; John A. Walker, vice-president and treasurer; George E. Long, secretary. Judge Joseph D. Bedle was re-elected as counsel.

The Northern Engineering Works, crane builder, Detroit, Mich., has furnished the power plant of the Edison Sault Electric Company, Sault Ste. Marie, Mich., with a second 15-ton alternating-current electric traveling Northern crane. It also advises that among recent improvements in the car stations of the International Railway at Buffalo are four three-motor electric Northern traveling cranes, 10 tons capacity; also one overhead electric track and trolley.

The new factories of the Bird-Archer Company, manufacturer of Bird-Archer boiler compounds, are in course of construction in Jersey City and will be completed in the early part of the summer. The entire laboratory staff and manufacturing staff will be located in this main factory, and with improved facilities, as planned, this will be, it is said, one of the largest and most completely equipped factories for feed-water analysis and boiler-compound manufacture in the country.

The Lagonda Manufacturing Company, Springfield, Ohio, has brought out a publication, on "Boiler Scale and its Removal," which is designated Catalog F, but which is really a treatise on the subject mentioned. It it a 48-page book containing many facts about boiler scale worth knowing, and including also forty illustrations of the method of removing scale by means of the Weinland cleaners made by this company. The book will be sent free to all who write for it. It is very attractively got up.

E. H. Kellogg & Co., 243 South street, New York, manufacturers of anti-corrosive cylinder-oil, have received a letter from the Cannock Chase Collieries Company, Walstall, in which the latter states that it has been using the oil for more than 20 years, in air-compressor cylinders, as well as in other cylinders, with the greatest success. They add that they have never received a com-

plaint from any of their men about this oil. E. H. Kellogg & Co. inform us that their export business is constantly increasing.

The A. D. Granger Company announces the change in its New York office to rooms 1518, 1519 and 1520 West Street building, 90 West street, where much larger and more commodious offices have been arranged for the better conduct of its business. The company still handles products of the Skinner Engine Company, Oswego Boiler and Engine Company, Harrisburg Manufacturing and Boiler Company, Union Iron Works, of Erie, Penn., Bates Machine Company, of Joliet, Ill., and Frost Manufacturing Company, of Galesburg, Ill.

To provide adequate quarters for rapidly increasing business, the Quaker City Rubber Company, of Philadelphia, has removed its offices to 629 Market street, where, with double the floor space and greatly improved facilities, it is in a better position to meet the large demand for the famous "P. P. P." packing. It is to the operating engineers' appreciation of the qualities of "P. P. P." packing that the Quaker City Rubber Company owes much of its growth, and, ever mindful of this fact, it will still further endeavor to give that satisfaction which has so strongly developed the business friendship between this house and the operating engineer.

The Lagonda Manufacturing Company has erected a new plant at Springfield, Ohio. This plant was made necessary by the increased demand for Weinland boiler-tube cleaners and other specialties made by this company. The main building is 50x200 fet, and, although not first in size among modern factories, is a model in the character of its construction and equipment; and it is undoubtedly the largest plant in the world building boiler-tube cleaners. The walls and floor are of artificial stone, and both floors are well heated, lighted and ventilated. It has modern wash-rooms, lockers and toilets. Every machine tool is driven by an individual motor receiving power from a gas-engine driven generating plant.

The Harrisburg Foundry and Machine Works, through its St. Louis sales office, the E. H. Abadie Co., has entered into a contract with the United States Government for the manufacture of two twin tandem compound engines of 1000 h.p. each, for installation upon two modern dredge boats to be used in connection with the Mississippi River Commission's work of establishing a channel in the Mississippi river. This company has also entered an order from the Government for one tandem compound engine of 350 idicated hore-power for direct current to a 200-kilowatt General Electric generator, to be installed at Panama, to be used in connection with the work of the Canal Commission at that place.

The Lunkenheimer Company, Cincinnati, Ohio, has established its eastern office and warehouse in much more commodious quarters in the building at 66 and 68 Fulton St., New York, recently erected, Alfred J. Jupp managing this division of the company's business. A very large and complete stock is carried in the new warehouse, and in addition to utilizing New York as a distributing center for the eastern territory and coast trade, the exacting details relating to much of the company's export business are supervised at this office. Special care is given to the packing of all breakable and polished material in serviceable wrapping in attractive dovetailed slide-cover wood boxes, after careful wrapping in paper especially adapted to this purpose, applying alike to all goods, whether designed for domestic or foreign trade.

The Garlock Packing Company has moved its Pittsburg offices to the corner of First avenue and Smithfield street, occupying the entire third floor of the new Thaw building. The entire floor was especially arranged for the company's use and is one of the finest and most convenient packing and rubber stores. On April 27 the company held "open house" in the new store, to which had been invited a number of friends and customers, including the different engineering societies. More than 1000 visitors were registered. Decorations of palms and flowers, with an orchestra and refreshments, made the event very complete, and served well to acquaint every one with the new location. Owing to the increased facilities for handling business, the Garlock company expects to carry a complete line of all kinds of rubber goods and materials used in the engineering trade.

The General Electric Company has received a contract for the electrical equipment of a temporary power plant at Spanish Fork, near Vernal, Utah, in connection with the so called "Strawberry valley project" for the irrigation of ranches, under direction of the reclamation service of the Geological Survey. A 45-foot dam is to be built across the Strawberry river and eventually a power house of 2250 kilowatts capacity will furnish current for lighting several small towns and driving centrifugal irrigation pumps. The temporary outfit will include two 425-kilowatt, three-phase, alternating-current generators direct-connected to Leffel water wheels, with step-up transformers, two belt-driven 45-kilowatt exciter generators, and two sub-station motor generator sets, consisting of 75- and 50-kilowatt direct-current machines direct-connected to 157- and 125-horse-power 2080-volt induction motors.

The Kennedy Valve Manufacturing Company, of New York City, is building a new plant in the city of Elmira, N. Y. In many respects it will be unique in its construction and equipment, being of such nature that the constantly improved methods and appurtenances in the manufacture of its product can be easily installed, and further extensions can be made without interfering with the present arrangements, thus enabling each department to expand independently of another as occasion requires. The modern industrial track system connecting all departments, together with the overhead traveling cranes, and the operation of the plant electrically, enables the above outlines to be advantageously carried out. The new plant is located at the east end of the city on a site consisting of 21 acres of ground connected, by special arrangement, with the four trunk lines which run through the city—Delaware, Lackawanna & Western, Erie, Lehigh Valley and Pennsylvania railroads—thus giving the company unexcelled shipping facilities. The buildings now under construction and nearing completion are the pattern shop and storage building, iron foundry, iron machine shop and warehouse, power house and brass foundry. The other buildings contracted for are brass machine shop and general office buildings. The buildings under way are built with concrete foundations, walls of brick, laid in portland cement, roof trusses and columns of steel, with five-ply asphalt roof.

New Equipment

Portsmouth (Va.) Gas Company will enlarge its central plant.

The city of Sayre, O. T., has voted to issue $25,000 bonds for water works.

The city of Lawrenceburg, Tenn., will erect water works and lighting plant.

The Clifton Forge (Va.) Light and Water Company will erect an ice plant.

The Alturas (Cal.) Electric Light and Power Company will enlarge its plant.

The Clinton (Iowa) Gas Light and Coke Company will erect a new retort house.

The Atkins Milling Company, Wirtz, Va., contemplates installing an electric-light plant.

The Cleburne (Texas) Gas and Electric Company will increase the capacity of its plant.

The Janesville (Wis.) Electric Company is planning to install a new 200-horse-power boiler.

The Stearns Gas Engine Company, Los Angeles, Cal., is constructing a new $10,000 factory.

The city of Batesburg, S. C., contemplates increasing the water supply and erecting a light plant.

The Beloit (Wis.) Water, Gas and Electric Company is planning to increase the capacity of its plant.

The Grays Harbor Light and Power Company, Aberdeen, Wash., will erect a new power plant.

The city of Vienna, Ga., will expend $15,000 in installing electric light and sewerage systems.

The Lowell (Mass.) Electric Light Corporation will build a new plant at Belvidere to cost $250,000.

Chandler & Taylor, engine and boiler builders, Indianapolis, Ind., will build an addition to their plant.

The city council of Gridley, Ill., is said to be considering the establishment of an electric-light plant.

G. L. Pillsbury, of St. Paul, Minn., is preparing plans for an electric light plant for Rochester, Minn.

An addition will be built to the electric light plant at Topeka, Kan. H. K. Goodrich is superintendent.

The Rockwood (Pa.) Electric Light Company contemplates installing a 100-kilowatt unit in its plant.

A new boiler has been recommended by the mayor of St. Joseph, Mo., for the municipal electric light plant.

The Harbison-Walker Refractories Company, of Pittsburg, Penn., will erect a large plant at East Chicago.

The Delavan (Wis.) Light and Fuel Company is contemplating changing the electrical equipments of its plant

The city of Cordell, O. T., has voted the issuance of $20,000 bonds for water-works and electric-light plant.

L. F. Gaines and others, of South Boston, Va., will establish a steam laundry and ice plant. Capital, $25,000.

Reeves Bros., Columbus, O., have incorporated as the Reeves Gas Engine Company and will build a new plant.

The citizens of Bedford City, Va., are contemplating doubling the capacity of the municipal electric-lighting plant.

The Rhode Island Company, Providence, R. I., operating electric railways, will enlarge one of its power plants.

The Beatrice (Neb.) Gas and Power Company is contemplating the expenditure of about $40,000 for improvements.

The New Mexico Light, Heat and Power Company is contemplating the enlargement of its plant in Silver City, N. M.

The Consolidated Railway Company, of New Haven, is contemplating the construction of a sub-station at Middletown, Conn.

The new ice and electric plant to be installed by the Del Rio (Texas) Electric Light and Ice Company will cost about $40,000.

The city council of Franklin, La., has adopted plans and specifications for a new municipal electric light plant to cost $30,000.

New Catalogs

C. Yingling & Son, 150 Broadway, New York. Circular. Yingling shaking grate. Illustrated.

J. M. Smith, 568 St. Marks avenue, Brooklyn, N. Y. Circular. Byrar friction lock-nut. Illustrated.

Crane Company, Chicago, Ill. Pamphlet. Crane specialties. Illustrated, 96 pages 4x6½ inches.

F. E. Keyes & Son, 20 Broad street, New York. Folder. Advance boiler feed and purifier. Illustrated.

E. M. Carr Pump Governor Company, New Catle, Penn. Circulars. Steam pump and oil pump governors.

Western Gas Engine Company, Los Angeles, Cal. Catalog. Gas engines. Illustrated, 62 pages, 6x9 inches.

The Norbert Wolff Company, 470 Greenwich street, New York Circular Belt dressings. Illustrated.

F. E. Keyes & Son, 20 Broad street, New York. Pamphlet. Advance feed water purifiers. Illustrated.

Franklin Filter Company, 308 North Commercial street, St. Louis, Mo. Circular. Oil filter. Illustrated.

The Lyman Manufacturing Company, Buffalo, N. Y. Circular. Farrel-Lyman ball disc valve. Illustrated.

Dubois Iron Works, Dubois, Penn. Catalog. Gas and gasolene engines. Illustrated, 35 pages, 6x9 inches.

Jenkins Bros., 71 John street, New York. Catalog. Valves and packings. Illustrated, 128 pages, 6x9 inches.

Buffalo Forge Company, Buffalo, N. Y. Catalog No 77 Blacksmith tools Illustrated, 38 pages, 3½x6½ inches.

Clinton Wire Cloth Company, Clinton, Mass. Catalog. Clinton wire lath. Illustrated, 51 pages, 6x9 inches.

Fairbank, Morse & Company, Chicago, Ill. Catalog No. 114. Practical Irrigation. Illustrated, 36 pages, 6x9 inches.

American Wire Brush Company, 25 Broad street, New York. Catalog Wire Brushes. Illustrated, 16 pages, 6x9 inches.

Philadelphia Gear Works, Incorporated, Philadelphia, Penn. Catalog. Gears. Illustrated, 72 pages, 6x9 inches.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WANTED — Experienced draftsman for stoker design. State experience and salary expected. Box 217, POWER.

MECHANICAL ENGINEER and draftsman wanted, experienced in power station work; state experience and salary required. Box 239, POWER.

WE HAVE a first-class position open for mechanical draftsman and engineer who is familiar with duplex pump designing and shop practice. Box 244, POWER.

WANTED—A competent traveling salesman on fan and motor business; must understand direct current motors and special motor application; a good position for the right man. Answer by letter, state experience and give references. The Eck Dynamo & Motor Company, Belleville, New Jersey.

VALVE AND STEAM GOODS DESIGNER. Wanted, by a concern in the middle West manufacturing valves and steam accessories, a young man capable of taking up the details of designing and manufacturing; one with technical knowledge preferred. Write, stating age, experience, references and salary required, Box 247, POWER.

WANTED—Experienced chief engineer for electric-power plant of 25,000-kw. capacity, operating compound reciprocating engines, steam turbines and gas engines; a permanent and well-paid position for competent, responsible man; give detail of experience, present position and salary. E-20, Room 1300, Trude Building, Chicago, Ill.

WANTED—Electrician, $1400 per annum, navy yard, Pensacola, Fla.; a competitive examination will be held simultaneously for the above position at the navy yards, Brooklyn, N. Y., Washington, D. C., New Orleans, La., and Pensacola, Fla., June 5, 1907. For further information address commandant of the yard at which the applicant desires to be examined.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED by young man (25), with six years' experience erecting and repair work, steam fitting, hoisting engineer. Box 236, POWER.

SALESMAN, hustler, valuable connection and practical experience with machinery, desires to represent manufacturers in Canada. Box 243, POWER.

GAS ENGINEER, large experience in erecting and operating producer-gas engine plants, would take charge of power plant or erecting work. Box 242, POWER.

MECHANICAL ENGINEER, expert on steam turbines, able to make any calculation, an able and inventive designer, wishes position as assistant to chief engineer. Box 246, POWER.

POSITION WANTED—Thoroughly practical engineer; long experience management and operating steam, electrical and water-power plants; first-class references. Box 240, POWER.

WANTED—Position by first-class engineer; 13 years' experience in engine room, 8 years with Corliss engines and electrical machinery; am capable, sober and steady; hold highest references. Box 245, POWER.

MECHANICAL ENGINEER traveling in Europe this summer wants to correspond with parties desiring informations, reports, representation, etc., of technical nature; has successful experience in this work Box 225, POWER.

ENGINEER AND MACHINIST, 35 years, single, sober and steady having a marine and stationary license, wishes a position to take charge or as assistant engineer, preferably out of town. Theo. E. Brady, 583 Broome St., New York.

A YOUNG GERMAN draftsman and engineer (married) is looking for a position as an engineer; besides having served 3½ years as engineer on large vessels, other evidences of skill and fitness can be furnished. Address "C. B.," 816 West Baltimore street, Baltimore, Md.

AS ENGINEER of an ordinary steam plant, or assistant engineer in a light or power plant. Have 7 years' practical experience, an I. C. S. engineer's diploma and a first-class Ohio license; understand using indicator; can give references; wil go any place in United States or Canada after June 1. J. D. Fox, Greenville, Ohio.

WANTED—Position as chief engineer or master mechanic of plant or superintendent of repair shop; competent to install, operate and repair steam, refrigerating and electric machinery. Experience: four years' apprenticeship machinist trade, 11 years engineer at sea, locomotive and marine repair; hold U. S. license chief engineer ocean steamers unlimited tonnage; references; age 32; strictly temperate and attentive to business. At liberty June 1. Box 235, POWER.

Miscellaneous

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WE DESIRE a few more machines or specialties to manufacture. Box 423, Troy, N. Y.

WANTED—Air compressor, straight line, about 250 ft. air at 100 lb. pressure. Must be in first-class condition. Box 241, POWER.

IF YOU DESIRE to learn the latest improvement in steam boilers correspond with the Detroit Water Tube Boiler Co. See their advertisement on page 174.

ENGINES AND BOILERS, ⅛ to 2-h.p. engine castings in sets. Models and general machine work. Sipp Electric and Machine Co., Paterson, N. J. Catalog 4c.

PATENTS—H. W. T. Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make free examination and report if patent can be had, and exact cost.

BEST COAL for gas producers is the Bernice Pea coal, 9 per cent. volatile matter; ask for analysis and prices; shipment via L. V. R. R. and connections. Charles W. Mooers, Elmira, N. Y.

ENGINEERS AND FIREMEN — Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass avenue, St. Louis, Mo.

EUROPEAN GENTLEMAN desires novelties, particularly novelties which can be manufactured in large quantities and placed on the market at moderate cost; desirable, but not imperative that patent protection be afforded; royalty contract or purchase agreement if suitable articles can be found; large and heavy manufacturing not undertaken; electrical devices especially. Address communications with full disclosures to Thomas J. Johnston, 11 Pine treet, New York City.

For Rent

LARGE FLOORS for rent, 60x210 ft., in thriving country town near Boston and Providence. Steam and electric power, light and heat. Railroad switch. Box 222, POWER.

For Sale

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

FOR SALE—One 25 h.p. Allfree steam engine, little used and in perfect condition. Crist, Scott & Parshall, Cooperstown, N. Y.

A GOOD SPECIALTY FOR SALE—Shop rights or exclusive license to build The Rider Ammonia Compressor. F. A. Rider, Pittsburg, Pa.

FOR SALE—Cyclopedia of electricity; five volumes, three-quarters red morocco, leather binding; books are in fine condition; used but short time; cost $19; will sell for $9. Address "R. S. M.," POWER.

FOR SALE—A slightly used engineering library. Steam, electrical, mechanical. Twelve volumes bound in three-quarters red morocco leather. Cost new $60. Will sell for $18. Address "R. L. N.," POWER.

FOR SALE — Cyclopedia of engineering; steam, electrical, mechanical; bound in three quarters morocco; four volumes; cost new $19; are in fine condition; will sell for $9. Address "M. B. T.," POWER.

FOR SALE—Hydraulic accumulator, measurement 36-9-72, water weighed, running pressure 1500 lbs. to the square inch; never used—just as come from manufacturer. Write Winslow Bros. & Smith Co., Norwood, Mass.

FOR SALE—Western electric dynamo with rheostat, voltmeter, ammeter and slate switchboard, 120 volts 75 amperes. Patterson-Berryman feed-water heater, 100 h.p. Kellum draft regulator. All good as new. Box 237, POWER.

FOR SALE—Electric-light plant in first-class condition in prosperous little town of about 1500 in Ohio. Will bear investigation (cause of sale bad health). No one but strictly meaning business man need apply. Address Box 238, POWER.

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A One Hundred Horse-power Steam Plant

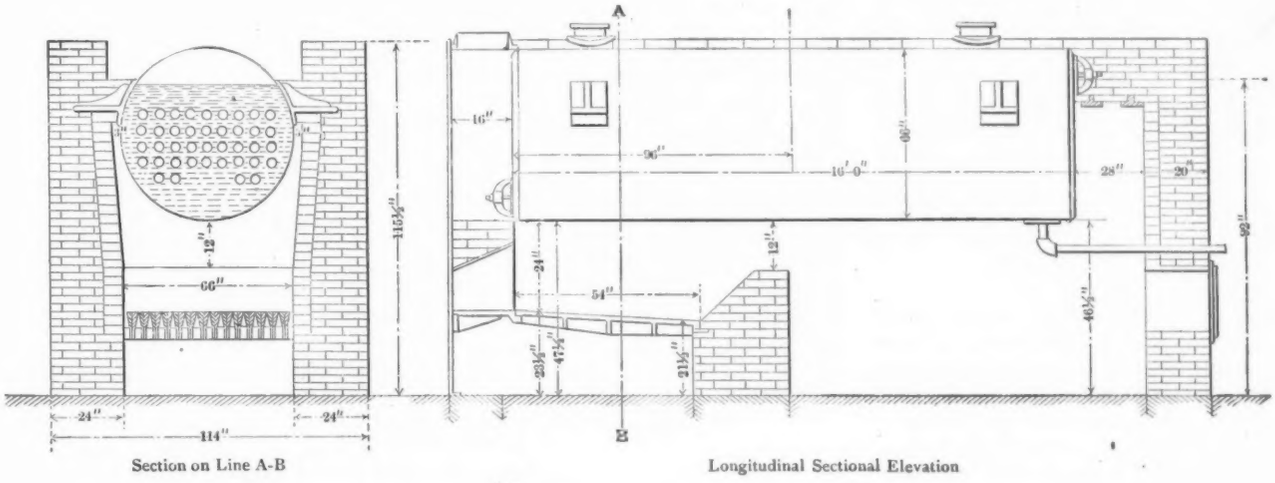
If You Were Called Upon to Design One, What Would It Be Like? Typical Examples, Both Real and Ideal, by Practical Engineers

It has been suggested that while the descriptions of large installations appearing in POWER *from time to time are interesting and instructive, descriptions of plants of moderate size would be of more practical use to a majority of the readers of the paper. To meet this suggestion, some time ago we invited contributions descriptive of plants of one hundred horse-power. Several of these are presented herewith and we should be glad to have them commented upon by our correspondents. There is far more aggregate power used in small units than in the great stations and usually less brainwork employed in providing for it. Improved design would result in greater aggregate saving to owners and greater satisfaction for more engineers than an equivalent improvement in large plants, and there is more chance to effect it.*

A Steam Plant for Developing One Hundred Horse-power

By James F. Hobart

The steam machinery described in this article was selected and arranged with a view of securing a fairly economical power plant for a reasonably moderate expenditure. It was not anticipated that great economy in fuel would be attained, nor was it expected that a "show" plant would be the result. It was expected, however, that the installation would prove capable of delivering the stated amount of power regularly six days in the week, ten hours per day, with a reserve capacity which would permit of a considerable extension when the growth of the business should demand an increase of power. For this purpose it was believed that the engine selected, a 14x30-inch type B Hamilton Corliss, would meet any extra demand by readily allowing an increase of revolutions per minute, and also by permitting an increase in the steam pressure with safety. This engine should easily develop 100 indicated horse-power at 90 revolutions per minute under 90 pounds gage pressure. The limit of the allowable pressure on this type of engine is 125



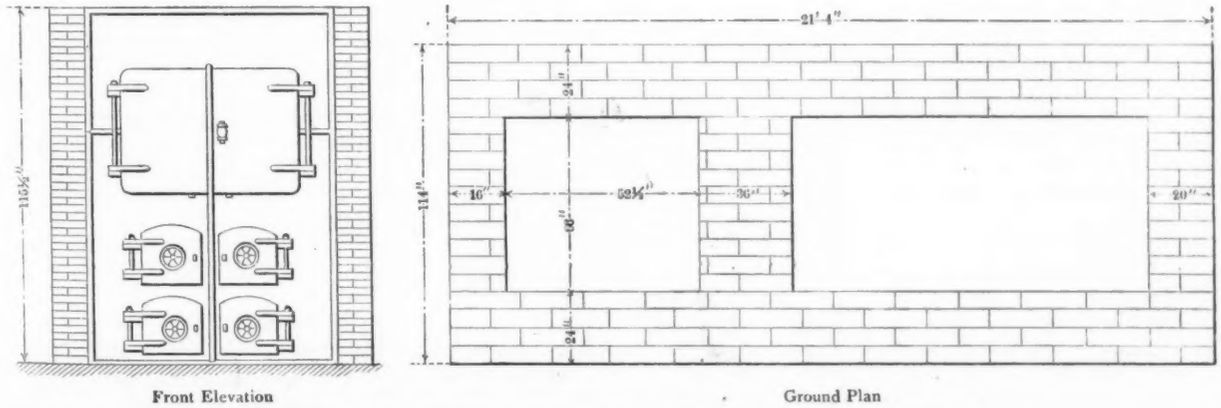


FIG. 1. SETTING FOR A 66-INCH BY 16-FOOT HORIZONTAL TUBULAR BOILER

pounds per square inch, and the maximum speed is 100 revolutions per minute. It was found that the most efficient cut-off at the pressure at which steam was used was at one-fifth. Increasing the admission to one-fourth, the steam pressure to 125 pounds and the revolutions to 100, the engine will develop 193 horse-power, thereby permitting a great increase in load without a great sacrifice of efficiency. The data of this engine will be given later.

The boiler selected was of the horizontal tubular type set with full-flush front and without dome or dry-pipe. The specification of the boiler is as follows: Diameter, 66 inches; length of shell, 16 feet; thickness of flange-steel shell, 13/32 inch; heads, ½ inch; number of 4-inch tubes, 58; length of tubes, 16 feet; stack, 30 inches by 60 feet, made of No. 12 steel. The grate is 66 inches wide by 54 inches long. The weight of the boiler is 13,300 pounds, and the weight of the fixtures is about 7050 pounds. About 21,000 common bricks will be required for the setting, together with 800 fire-bricks for the furnace lining.

How Strength of Boiler Shell Was Calculated

The strength of the boiler shell was calculated upon a minimum plate strength of 55,000 pounds, the upward limit of the flange-steel plates being 62,000 pounds. The plates were planed before riveting, and the calking was done with a Connery concave tool. All circumferential seams are single riveted, the rivet diameter and spacing being ¾ inch and 2⅛ inches, respectively. The longitudinal seams are triple riveted with butt-strap rivets ¾ inch diameter, spaced 3¼ inches and 6½ inches. The covering strips are 5/16 inch thick. The efficiency of the joint is 87½ per cent., and the allowable working pressure is 118.4 with a factor of safety of 5. The actual pressure is 131.6 pounds with a factor of 4½.

The shell was riveted by hydraulic pressure, and great care was taken not to put pressure enough on the riveting machine to force out the rivet so as to expand the hole in the plate. Provision was also made for making the rivets fill the holes perfectly without the possibility of forcing out a washer between the plates. The shell was made one sheet in circumference, and the longitudinal seams were turned up above the fire and water line. The tubes were all placed in vertical and horizontal lines, no tube being within three inches of the shell, nor within one inch of each other in vertical rows. The central space was two inches vertically.

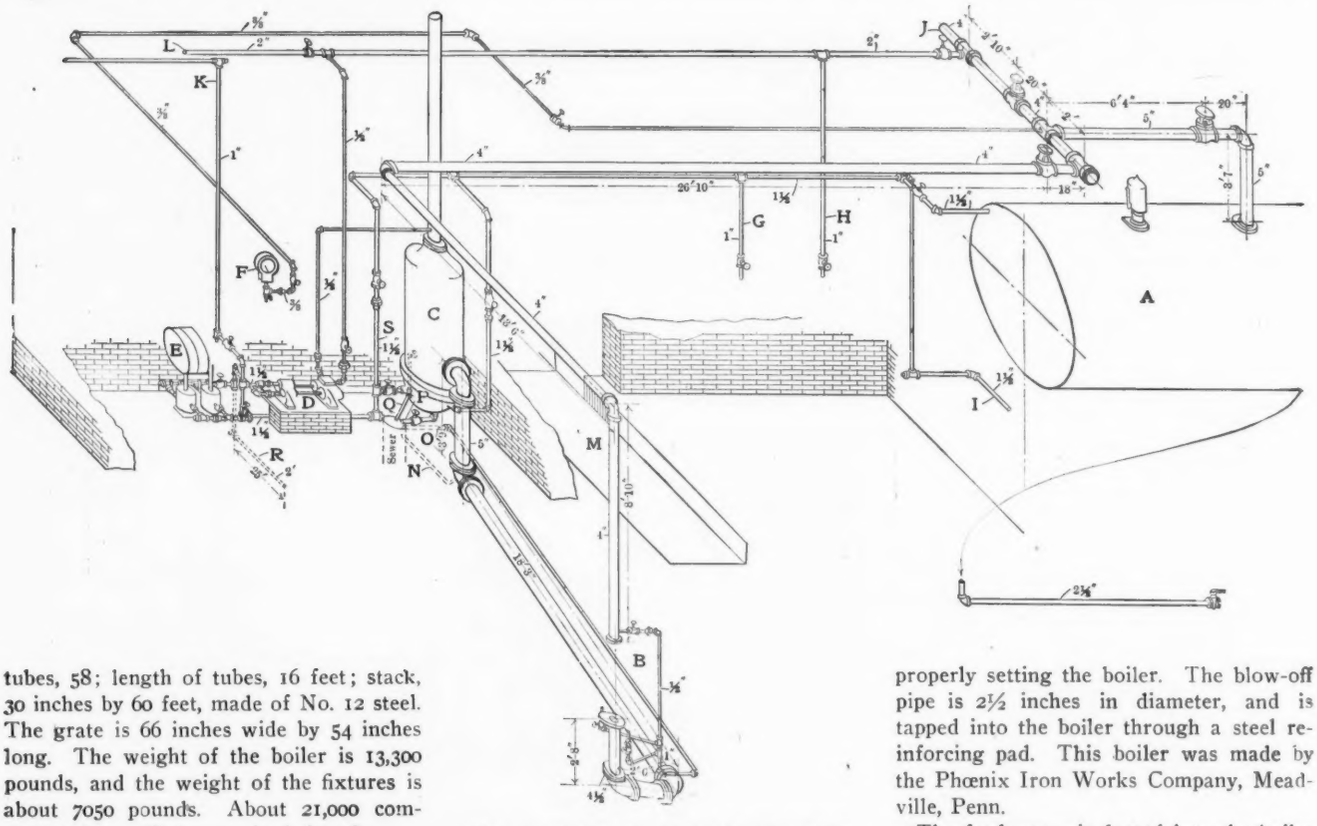


FIG. 2. ISOMETRIC DIAGRAM OF PIPING

One manhole was placed in the front head under the tubes, another manhole in the top portion of the shell; both were 11x15 inches, of Eclipse pattern. Below the tubes, in the back head, there was placed a 5x4-inch handhole. The boiler was tested to an hydrostatic pressure of 190 pounds per gage, and the riveting and calking were made tight at that pressure.

The feed-pipe enters through the front head, on the left side just above the water line. It is 1½ inches in diameter, and extends inside the boiler nearly to the rear head, then it passes across the boiler and terminates in an elbow placed to discharge horizontally toward the front end of the boiler, midway between the outer row of tubes and the shell. The heads are supported by adequate angle and through braces so disposed that the bracing does not carry over 6000 pounds per square inch of cross-section. The shell is supported upon pressed steel lugs riveted to the shell, and supported upon plates and rollers in such manner that the front end of the shell is fixed, leaving the rear end free to travel in accordance with expansion and contraction.

The rating of 100 horse-power is in accordance with the A. M. S. E. standard of 30 pounds of water evaporated at 70 pounds steam pressure from feed-water at 100 degrees Fahrenheit, or 34½ pounds at 212 degrees. The cast-iron boiler front is so arranged that the grate is 24 inches from the shell. The other setting dimensions are shown by Fig. 1, herewith, which contains all the dimensions needful for properly setting the boiler. The blow-off pipe is 2½ inches in diameter, and is tapped into the boiler through a steel reinforcing pad. This boiler was made by the Phœnix Iron Works Company, Meadville, Penn.

The feed-water is forced into the boiler by means of a belted pump when the engine is running, and by a steam pump when the engine is at rest. The belted pump is such as is furnished by Frank L. Patterson. The two single-acting cylinders are fitted with plungers 3 inches diameter by 6-inch stroke. The pump is back-geared and carries 18x5-inch tight and loose pulleys. Although it is too large for the boiler, it was purposely thus selected in order that it might be made to supply a second boiler for which space was left in the boiler room, as shown elsewhere by a plan of that structure.

The Steam Pump

The steam pump is of the duplex pattern, with double-acting cylinders 5¼x3½ x5 inches, and was furnished by the Advance Pump Company, Battle Creek,

Mich. This pump is also of sufficient capacity to supply two boilers. The heater, of the closed type, is made to carry full boiler pressure, the feed-water being pumped through the heater by either of the pumps mentioned above. The heater is technically known as the "Patterson-Berryman" type, and was supplied by the

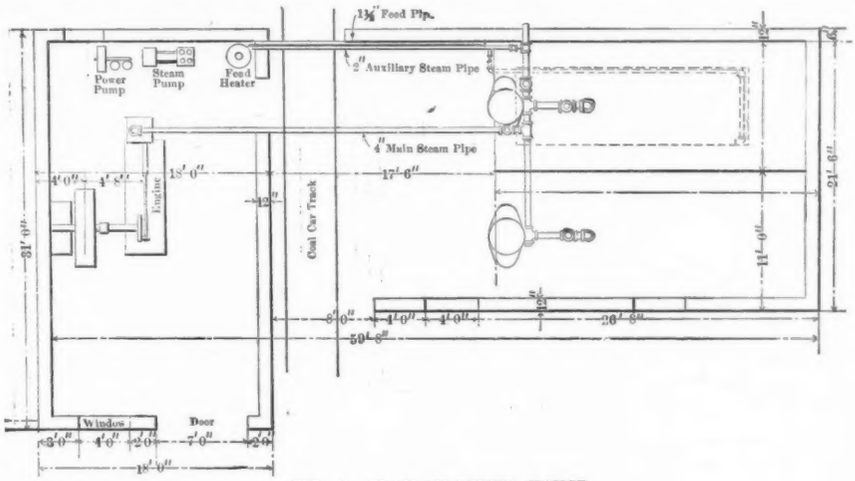


FIG. 3. PLAN OF POWER HOUSE

maker of the belted pump mentioned above. The size of heater used is known as the 18x68-inch, and its rating is based upon one-third of a square foot of heating surface per horse-power. This type of heater is claimed to deliver water up to its rated capacity from 70 degrees to 200 degrees upward. In addition to the exhaust and feed-water inlets and outlets, there are openings in the heater shell for the scum blow-off, the bottom blow-off, and a condensed-water discharge.

In the piping of the pumps and heater, as shown by Fig. 2, a by-pass is arranged in such a manner that either pump may be operated through or around the heater continuously and at will. That is, in case of derangement of the heater, it may be cut out by opening one valve and closing another, so the feed-water may be forced directly to the boiler without going through the heater, thus enabling repairs or cleaning to be effected at any time without stopping the steam plant.

The drawing Fig. 2, a combination of two ordinary elevations with a plan view, is made to scale, and the length of each and every piece of pipe may be taken off at will. While some engineers will desire a modification of the scheme there indicated, in order to suit local conditions, the piping as shown is sufficient for the proper operation of the steam plant. This drawing was made for the purpose of forming a check upon the man in charge of erecting the plant—presumably the engineer who was to run it after completion. Having erected several dozens of plants from this drawing, it was found to act as a perfect check against unnecessary additions to the list of pipe and fittings by the man upon the ground.

It has been the custom of the writer to send out with the machinery for each plant contracted for pipe and fittings sufficient to pipe the plant as shown by the diagram. Upon obtaining a settlement, up would come a bill for pipe and fittings, ranging anywhere from $50 to $100, for extra pipe and fittings under the plea that "insufficient material was sent to properly pipe the plant." With a 24x36-inch blueprint of Fig. 2 before him, there is no chance for anyone to work in a lot of pet cross-connections and fancy piping, and then charge up the material on account of "insufficient material furnished." With the blueprint in hand, every piece of pipe furnished can be checked off, and all fancy extras charged just where they belong. It is not as much work as it looks to make up such a drawing of a pipe system, and it is well worth ten times its cost in contract erection, for which, as well as for all other purposes, it beats the plan and elevation drawings "clear out of sight."

In Fig. 2 the boiler is shown at *A* and

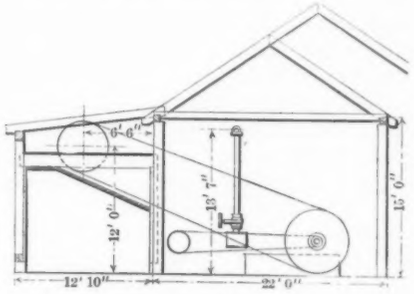


FIG. 4. CROSS-SECTION THROUGH POWER HOUSE

space is left for the engine at *B*. This space was left vacant in order that the cylinder drips and steam-pipe drain could be more clearly shown. The heater *C* has drips shown at *P* and *Q*, and the exhaust drip enters the sewer opening with the other drip-pipes at *N*, as also does the engine drip *O*; *D* and *E* represent the steam and belted boiler feed-pumps with their connections. At *F* is laid down a Bristol recording gage, style No. 9116, fitted with No. 75 charts. It is supposed that the gage is located in the office of the factory or anywhere else it may be desired. Such a gage is a good and profitable check upon both engineer and fireman—and the coal pile as well.

Arrangement of the Steam Machinery

The arrangement of the steam machinery in this plant was planned for either of two engine types, and several have been built of each. Fig. 3 shows the arrangement followed when a high-speed automatic engine was to be used instead of the Corliss. The boiler house was made large enough to permit of another boiler being placed therein and as shown in this drawing, also by Fig. 2, the main steam pipe is plugged to receive a main from the second boiler. Coal is received upon cars holding about 10 tons each, these cars being filled directly from gondolas upon a trestle outside of the boiler

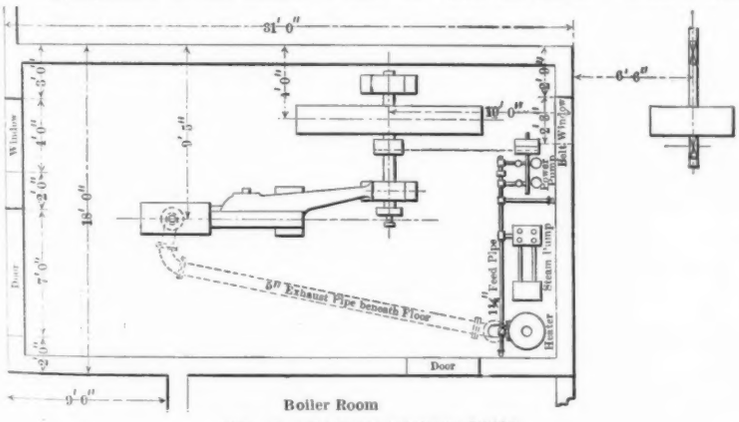


FIG. 5. PLAN OF ENGINE ROOM

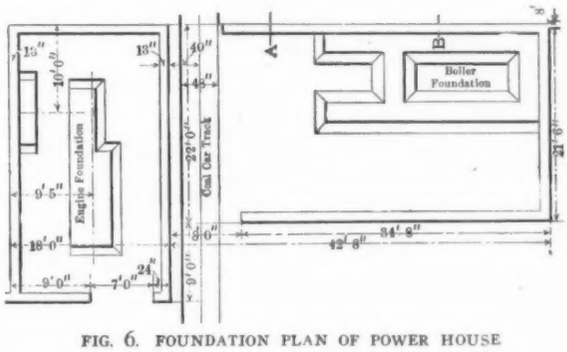


FIG. 6. FOUNDATION PLAN OF POWER HOUSE

house. The disposition of the coal trestle and track is such that the small cars may be filled with ashes in the boiler room, when empty of coal, then run by means of a winding drum directly upon the coal trestle and the ashes dumped into the cars which brought the coal. There is room for two of the small coal cars in the boiler room at the same time, thus allowing one car to be kept in the house until filled with ashes, whereupon it would be pulled out of the house, and a car full of coal substituted. After the coal had been burned or dumped upon the floor, the car was utilized for another accumulation of ashes. It will be noted that the car track is sunk 12 inches, in order to make it easier to handle coal and ashes to and from the cars.

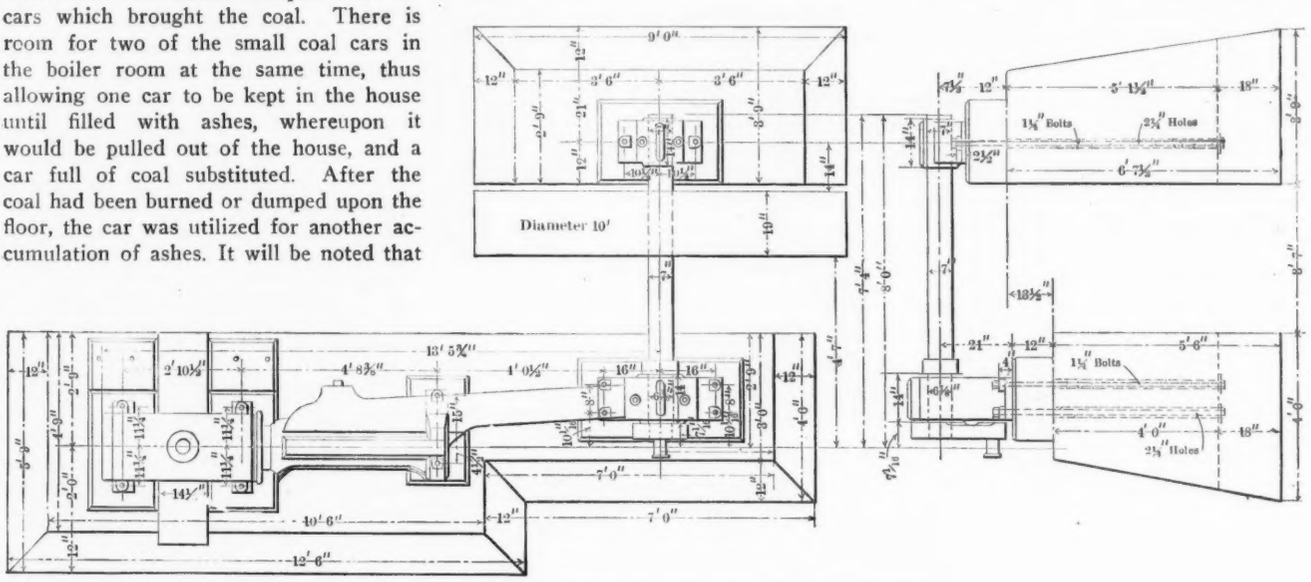


FIG. 7. PLAN AND END ELEVATION OF ENGINE FOUNDATION

It will also be seen in Fig. 3 that there is a pulley on the engine shaft directly in line with the pulley of the belted pump. The reason for this, aside from its convenience for driving the belted pump, is that most of the factories which have used the designs in question are naturally very dusty, owing to the nature of their business. It is chiefly to keep dust out of the engine room that the power pump was thus connected.

The pump belt connection is more clearly shown by Fig. 4, which was made to show the method of supporting the main shaft, especially on either side of the engine belt. This diagram also shows how the engine belt is boxed up to keep dust out of the engine room.

Fig. 5 illustrates the arrangement where a 14x30-inch Corliss engine is used, as described. It will be noticed that the arrangement of the pump belt is the same as that shown by Fig. 4. The belt is entirely out of the way, and is boxed in by the railing around the engine belt. The exhaust pipe makes a "bee line" to the heater, instead of extending straight out from the engine and thence to the heater parallel with the boiler-room wall. This arrangement was simply to save pipe. The plants being erected by contract, every six or eight feet of 5-inch pipe saved meant a little more on the right side of the ledger when the books were balanced.

By the arrangement shown, there was plenty of room all around the engine, the pumps were not crowded, and there was ample room to remove the steam-pump plungers when necessary. There was also plenty of room for a small generator in the engine room when the factory lighting had to be provided for.

Fig. 6 gives all the necessary data for the location of boiler and engine foundations. The plans for the boiler setting were set forth by Fig. 1, and little more need be said in relation to that part of the plant. The details of the engine foundation are given by the succeeding diagrams, and little descriptive text is needed in connection with the drawings. The boiler is shown against two walls of the boiler house, and the center lines of the engine cylinder and shaft are shown and dimensioned plainly.

Figs. 7 and 8 show the engine foundation in plan and in end and side elevations respectively. The dimensions contain all the data that can possibly be desired for laying down this engine in drawings of a power plant, or for building the foundation and for erecting the engine. No further description is necessary in connection with the drawings, as full descriptions of the engine and its parts are to be found later on.

Fig. 9 shows a very important factor in correct engine setting. With a good templet properly made and set, there should be no difficulty in placing an engine in proper alinement with the building or shaft; but if the templet be not properly attended to, it is impossible to set the engine with any degree of accuracy. The templet shown should be made of sound boards, free from large knots. It is preferably put together with screws, but clinch-nails make a very good, strong job when properly used. The proper way to mount a templet is to hang it up on several ledgers, which in turn are nailed to posts set far enough away from the engine foundation to allow convenient working space. The writer prefers to suspend the templet just high enough to permit of hanging the bolts in holes bored in the templet, the lower or pocket stones being

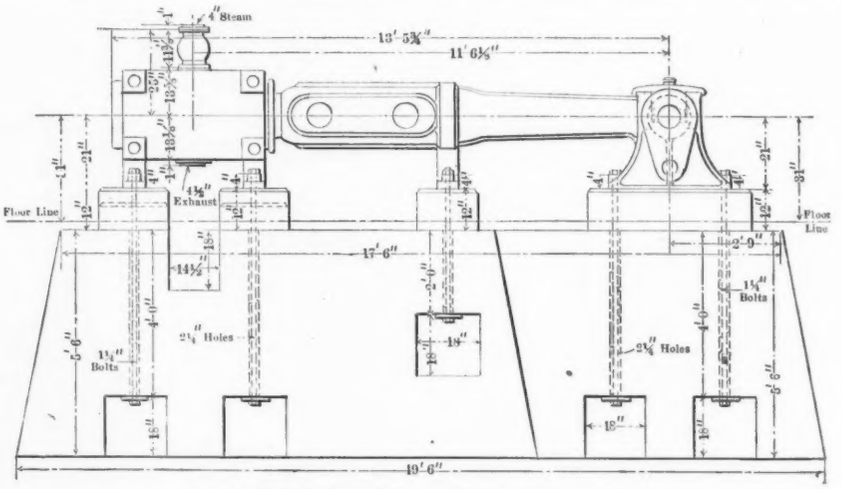


FIG. 8. SIDE ELEVATION OF ENGINE FOUNDATION

put in place and set directly from the bolts themselves. Pipe may be put around the anchor bolts if desired, but the writer prefers to let the masonry come directly in contact with the bolts, thus fixing them beyond all possibility of side movement. Such movement is very convenient if the foundation was not laid out with sufficient exactness, and it is desirable to shift the engine a very little in order to bring it into line with the shafting. Put the foundation

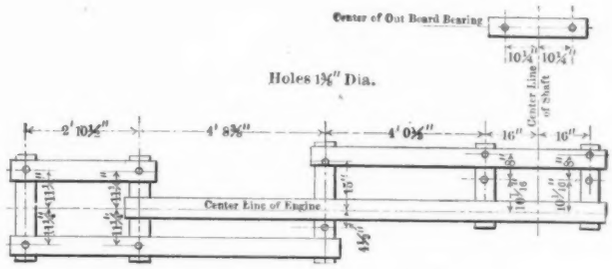
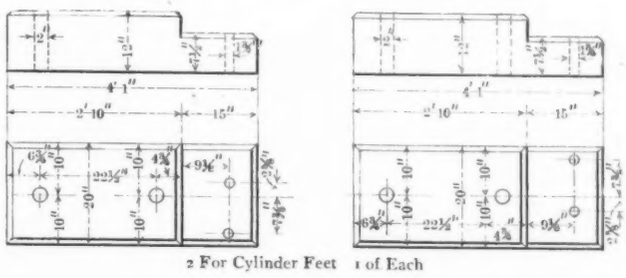
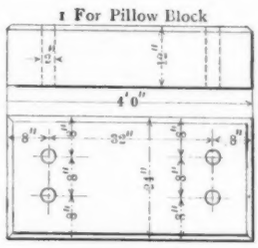
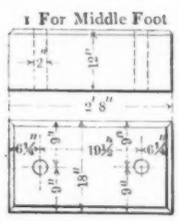


FIG. 9. TEMPLET FOR SETTING ENGINE







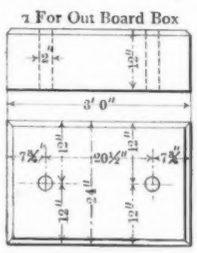


FIG. 10. CAP-STONES FOR ENGINE

or anchor bolts in correctly, plumb them nicely, then build the masonry solidly around the bolts, and the engine will stay where it is placed. By hanging the templet to the under side of the ledgers mentioned, the foundations may be carried clear up to the templet—something particularly desirable when concrete is used and there are no cap-stones. When, however, such stones are used it is not desirable to carry the masonry to its full hight, but it should be built up to the level of the lower edge of the cap-stones; then the anchor bolts will be immovably set and the templet may be removed, the cap-stones lowered into place over the bolts, leveled up and set, and the work will be completed without further use of the templet.

The cap-stones may be made of natural rock, or they may be poured into a mold to advantage, the proportions of 1, 2, 3 being used in the cement, sand and broken stone used. If the cap-stones are to be made of concrete, it will be found cheaper to pour the whole foundation rather than to bother with the cap-stones alone.

Description of Engine

The choice of an engine devolves upon individual opinion and the conditions of the service. Two reasons why this particular type was selected were low first cost and ease of keeping it clean on account of the absence of bright work. There are several other engines on the market which would answer the purpose equally well, and to the ordinary purchaser it would be largely a matter of price and delivery.

The bed-plate is of the well-known Corliss type, reaching directly from the main pillow-block to the front end of the cylinder. The pillow-block is cast upon one end of this girder, and the front cylinder-head bolted to the other end of the girder. The guides are cast upon the main girder of the bed and their faces thus brought directly above and below the crosshead pin, while the main girder of the bed is still kept up close to the central line of the engine.

The crosshead is so arranged that the guides receive the angular thrust of the connecting-rod at points directly below the center of the crosshead. The shoes of the crosshead are of steel and have immense wearing surfaces. The crosshead-pin is of steel and is provided with a glass oil cup, piped into communication with an oil-distributing cavity within the body of the pin. The crosshead is fitted upon the piston-rod on a taper, and is held by a cotter-key.

The cylinder is bolted to the end flange of the bed-plate, and has a separate front cylinder-head. The piston is cored out and braced with internal ribbing, and is fastened to the piston-rod by being forced upon a taper against a shoulder and locked with a key. Self-adjusting packing rings are used, and they may be taken from the cylinder only by removal of the follower-plate.

The engine is furnished with a complete set of graduated sight-feed oil cups. There is a centrifugal oiler, with a stand, for the crank-pin, a wiper cup for the crosshead and a large sight-feed cylinder lubricator for the cylinder.

Detailed Cost of Plant

The cost of this plant is approximately $6000, depending somewhat upon local conditions, the distance from where the several machines were manufactured, the character of the buildings, etc. Following is the price of the machinery, f.o.b. place of manufacture:

Engine, 24,000 lb.,	$1350
Boiler, 24,000 lb.,	847
Heater, 800 lb.,	78
Belted pump, 450 lb.,	90
Steam pump, 450 lb.,	80
Pipe and fittings, 2000 lb.,	150
Engine belt, 184 lb.,	154
Recording gage, 20 lb.,	54
23,000 common brick (laid) at $14 per 1000	322
800 fire-brick (laid in place)	25
Foundations for house, boiler and engine	500
Labor setting boiler	50
Labor setting engine	150
Labor piping, setting pumps, heater, etc.	65
Boiler and engine house, built by contract	2000
Total	$5912

No allowance is made for freight in the above figures, as that charge varies greatly in different parts of the country. As weights are given, each reader may figure the freight according to location.

The economy in fuel is not extremely great, as the plant was not designed for extreme economy. No tests of efficiency have been made, but the plant has been

operated ten hours per day, developing an average of 90 indicated horse-power, with a consumption of 3100 pounds of bituminous (mine-run) coal. This gives a coal consumption of 3 4/9 pounds of coal per horse-power-hour. The heating surface of boiler, the grate area and the ratio thereof to each other may be calculated from the data given, and the particular type of boiler setting used.

The operations of these small power plants is usually for ten hours per day, summer and winter, and is vested in two men, an engineer of high grade and a fireman who is competent to run the plant. It is customary to make the engineer foreman of the factory, give him all the labor necessary to handle coal and ashes, and he takes the responsibilty of the entire manufacturing plant as well as the power plant, keeping everything running and in repair.

A Model Hotel Plant

By M. B. Godfrey

The accompanying drawings represent the general plan of the steam and electric plant of the St. James Hotel, Washington, D. C. The plant is in the basement on the Sixth street side, and extends nearly the entire length of the building. The walls *X X X* in Figs. 1 and 2, are identical, and if the two plans are joined on those lines an idea of the whole layout will be gained.

The plant consists of two horizontal tubular boilers, two high-speed engines, two dynamos, one hydraulic elevator and a laundry installation.

Referring to Fig. 1, *A* A^1 are the boilers; *a* is the feed-pump; *b* the injector; *c* the receiving tank; *d* the vacuum pump for the heating system; *e* the feed-pipe which enters the boilers through the front heads and extends to the rear where it discharges in the space between the tubes; *f f'* are pop safety valves set to blow at 85 pounds; *B* is a 5-inch steam main leading from boiler No. 2.

This steam main passes around the front of the boilers, instead of across the top, as is usual, due to the limited space above the boilers, the smoke flue *F* just clearing the ceiling. This flue is 30 inches in diameter and extends (as represented by the dotted lines *F*) under the pavement in the areaway to the stack *G*. This stack is of iron, 30 inches in diameter and 92 feet high.

The blow-off pipe *g* discharges into the hot-well *x*; *E* is a 5-inch steam main leading from boiler No. 1. The 5-inch mains from the two boilers combine, as shown at G^1, and from that point a 6-inch main extends to the engine room; *e'* is a 1¼-inch by-pass connecting the two mains as shown; the pumps and injector are supplied from this pipe.

Referring to Fig. 2, *I* is a 12x11-inch Harrisburg standard engine, direct-connected to a 50-kilowatt Crocker-Wheeler generator *K*, and operating at 72 revolutions per minute. Steam for this engine is taken from the top of the main *H*, through the 4-inch branch *h*, and passes through the separator *i* to the engine; *L* is a 10x10-inch McEwen engine pumping at 285 revolutions per minute and belted to a 25-kilowatt Crescent Electric generator *M*. Steam for this engine is also taken from the top of a main through a 3½-inch branch. At *c'* is the switchboard; *N* is a 2-inch steam main which extends to a 10x6x10-inch Worthington duplex pump *O* of the plunger type. This pump is used for operating a Whittier hydraulic elevator *P*. The dotted line *K* represents the plan of the elevator shaft; *Q* and *Q'* are the elevator tanks, the open tank being directly above the pressure tank.

Method of Piping

The method of piping will be readily understood from the drawing: *R* is the main exhaust pipe from the engine and leads directly to the heater *S*, thence to the oil separator *l* and from there to the roof at *m*; *n* is a back-pressure valve, which is closed when the exhaust steam is needed for heating; the valve *o* is opened when the back-pressure valve *n* is closed and the exhaust steam then passes into the heating main *T*; *U* is the exhaust line from the pump *O*, and leads to the roof at *r*. By closing the back-pressure valve *p* on this pipe and opening the valve *t*, the exhaust passes through an oil-separator *s* to the heating main *T*.

When the exhaust is insufficient for heating, live steam is turned into the system by means of the valve *V*, and the automatic reducing value *U* maintains the desired pressure on the heating system. A 1-inch steam line *a'* extends to the hotel kitchen, where live steam is used for cooking, etc. The return line from the kitchen empties in the trap *b'*, which discharges in the main return *W*. All water of condensation is pumped by a 5x6x6-inch Burnham vacuum pump *d*, Fig. 1, into the receiving tank *c* in the boiler room. The main return pipe is located beneath the floor line, as shown by the dotted lines *W*; the portion above the floor is shown by the solid lines *y y* under the stairway, *Y*, leading from the boiler room.

The feed-pump *a* is a 5¼x3½x5-inch Knowles duplex pump, the speed of which is controlled by a float valve in the tank *c*. Hot- and cold-water supply pipes are also connected to the tank *c*, and by means of these the feed-water supply is regulated. A 2-inch main water supply enters the boiler room at A^2, and after passing through a trap, a meter and a Carter pressure filter B^2 the water is distributed to the different branches from *C'*. Power for the laundry machinery is furnished by a 10-horse-power Northern Electric bipolar motor, shown at D^2; E^2 and E^3 are Columbia washing machines; F^2 is an Empire mangle supplied with steam by the pipe C^1; the return pipe leads to the steam trap *d'*, Fig. 2, which discharges into main return pipe *W*; G^2 is a

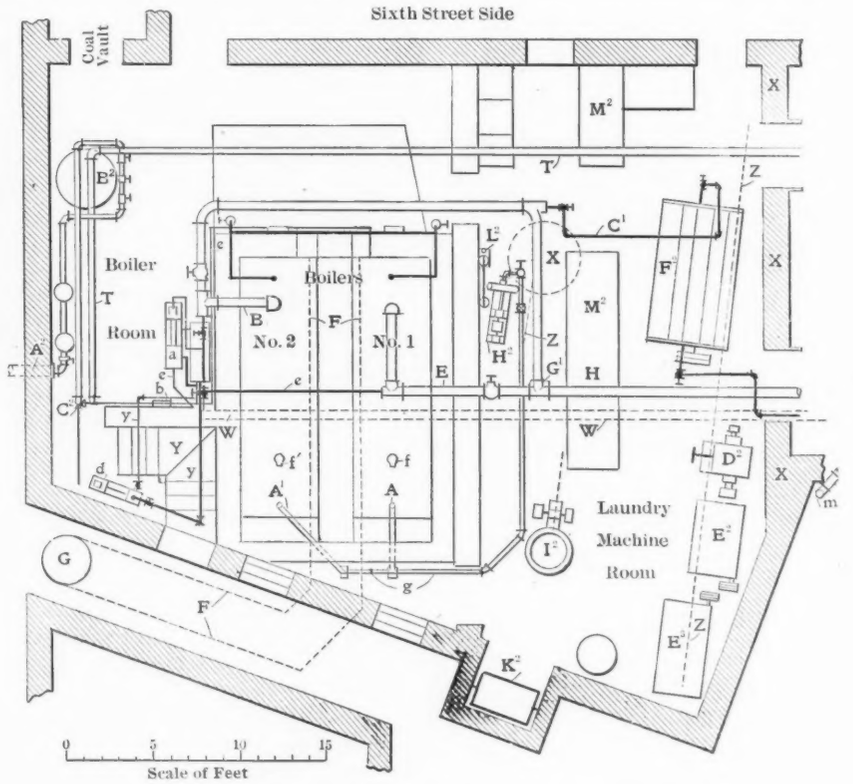


FIG. 1. BOILER ROOM, AND LAUNDRY-MACHINE ROOM

Crawford electrically heated ironing machine, and I^2 is a Columbia extractor.

All waste water from the laundry, as well as water blown from the boilers, empties into the hot-well X, from which it is pumped by a centrifugal pump H^2; K^2 is a lift for carrying linen to and from the laundry; the dotted lines Z extending across the laundry show the position of the shafting; L^2 is a Kendrick damper regulator, which regulates the draft; M^2 M^2 are tables for linen; N^2 N^2 Fig. 2, are ironing tables, where all hand ironing is done with electric irons.

The engines are oiled by a gravity system. The supply tank is shown at O^2 and the pipe g' distributes oil to the different bearings. The cylinder lubricators are filled from the tank P^2, by means of compressed air, which is taken from the elevator tank; R^2 and R^3 are oil tanks, and S^2 is an oil filter; T^2 is a tool board, U^2 a desk, U^3 a work bench, V^2 a motor generator for the telephone system, and W^2 are lockers.

to be done in the short space of about fifteen hours, this being a very objectionable feature.

This plant was remodeled six years ago, at which time the boilers, the 50-kilowatt unit and the laundry were installed. The 25-kilowatt unit has been in use for the past ten years. The elevator machine was installed about eighteen years ago, and has been in continual use since.

Cost of the Plant, Installed

Following is shown the cost of power plant, installed:

Boilers, accessories and steam main	$2468
McEwen engine and Crescent dynamo	3000
Harrisburg engine and Crocker-Wheeler dynamo	2399
Switchboard	330
Heater	220
Steam-pipe coverings	225
Total	$8642

horse-power of the elevator pump, running at the average speed (based on 24 hours' run) is 10 indicated horse-power, which makes a total average load of 62 horse-power. From the above figures the reader will note that the electrical load equals $\frac{35}{62}$, or 0.565, of total load, and by certain deductions the cost of generating the electric current can be closely approximated. The total operating expense being $20.10, that chargeable to the generation of current equals $20.10 × 0.565, or $11.36. This is really an excessive amount to be charged against the cost of current, inasmuch as the exhaust steam is used for heating, and furthermore the engineers do considerable work that is not connected directly with the steam plant. The electrical load, which is 190 amperes at 110 volts, running 24 hours per day, reduced to kilowatt-hours equals

$$\frac{190 \times 110 \times 24}{1000} = 501.6$$

kilowatt-hours. The cost of production as

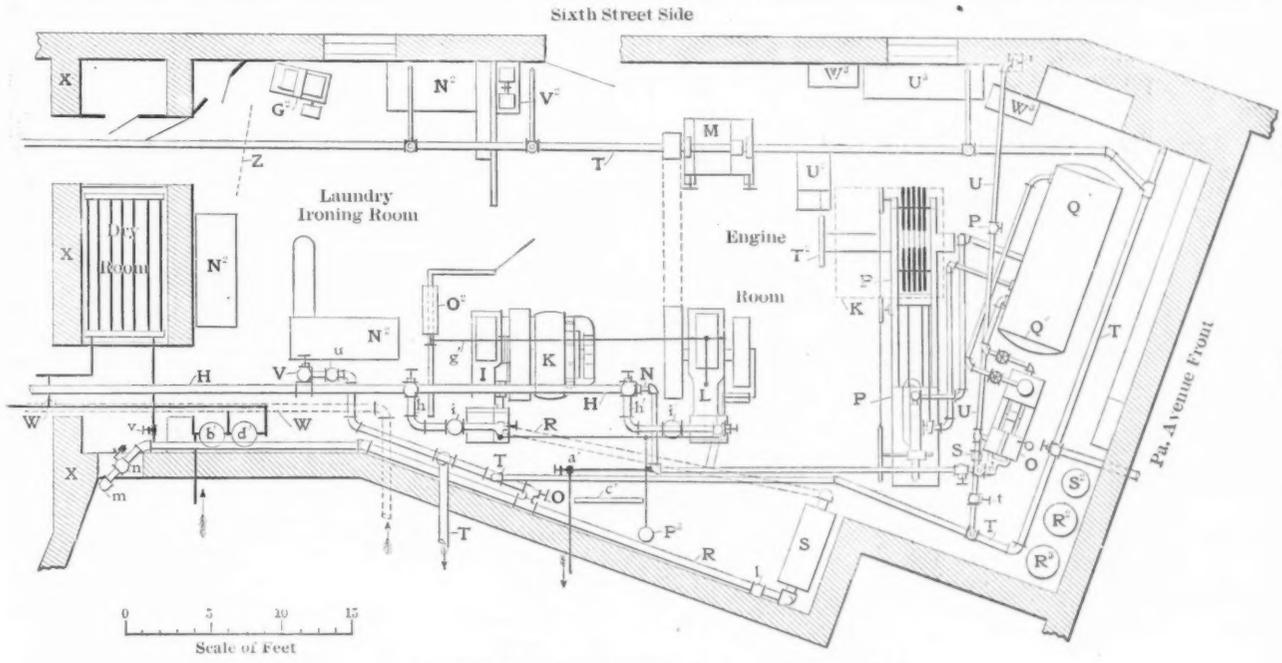


FIG. 2. ENGINE ROOM, AND DRYING AND IRONING ROOMS

This plant is in continual operation, the house having no source of light other than the isolated plant. The electrical load varies from 100 amperes (110 volts) to 420 amperes, the average load for the twenty-four hours being 190 amperes. The laundry is in operation ten hours every day and the kitchen is open eighteen hours daily, so considerable live steam is used in these two departments.

The boilers were made by the Oil City Boiler Works, and are 54 inches in diameter by 15 feet long and have sixty 3-inch tubes each. The setting is of the usual form with furnaces 4½x4½ feet in which are used the ordinary "herring-bone" grate-bars. Both boilers are needed for the night load, and for this reason all repairing, cleaning, inspection, etc., has

The average daily expense for supplies and the cost of attendance are as follows:

3 tons bituminous coal (2240 pounds each)	$12.00
Packing, waste, oil, repairs, etc.	0.80
3 engineers, average daily wages	7.30
Total	$20.10

Without proper means for determining the daily consumption of feed-water, it is hard even to approximate the average horse-power of a plant of this kind. As near as can be determined by close observation, the live steam for the laundry and kitchen represents about 15 horse-power; the indicated horse-power of the engines when carrying the average load is 35 indicated horse-power. The indicated

found above being $11.36, the cost per kilowatt-hour is readily found as follows:

$$\frac{11.36 \times 100}{501.6} = 2.3 \text{ cents}$$

per kilowatt-hour, which is much cheaper than current can be supplied by the average central station.

Placing the central station rate at the low figure of 4 cents per kilowatt-hour, the amount saved by using the isolated plant would be, $0.04 - 0.023 = 0.017$, or 1.7 cents per kilowatt-hour, and 501.6 kilowatt-hours $= 501.6 \times 0.017 = \$8.53$. The interest at 6 per cent. on the money invested ($5729) in the two units and switchboard amounts to $\$5729 \times 0.06 = \$343.74$, or 94.2 cents per day, while by investing the same amount of money in the isolated plant, a net saving of $8.53 —

0.942 = $7.59 per day, which shows a saving ample to allow for depreciation due to wear and tear of machinery, and it would still be a paying investment. This plant is in excellent state of repair.

Steam-power Plant of One Hundred Horse-power Capacity

By C. R. McGahey

In the following description of a steam-power plant of 100 horse-power capacity, it is designed to use a return-tubular boiler, a boiler-feed pump of standard make, a supplementary injector, a feed-water heater of the inclosed type, and a four-valve Corliss engine. The class and cost of the building will be omitted, as this is usually left to the fancy of the owner. The foundations and locations of the machinery need to be considered as part of the plant, of course, and the cost of excavation will be based upon that for removing clay, which is between the cost of excavating stone and sand, the two extremes. Suppose the plant to be built east of the Mississippi river, as a convenient section for reckoning with the question of freight.

The entire plant will be built under the supervision of a "working foreman," to insure good work. First, he will lay out the positions for the machinery from the drawings furnished by the builders, Fig. 1 herewith being a plan showing the layout of a 66-inch by 16-foot boiler, a steam pump, a heater, and a 12x22-inch engine arranged to suit the conditions and set as compactly as possible.

The excavations for the boiler walls should be 18 inches deep, and 18 inches wide for the side and end walls; for the bridge walls the excavation will be 6 inches deep and 30 inches wide. It will be necessary to remove 4½ cubic yards of clay at a cost of $2.90, to which should be added $1.25 per day, for practically 2¼ days, which the laborer would get for the work. The excavation for the engine foundation could be done at the same time, the demensions being as follows: Length, 13 feet; depth, 5 feet; width, irregular; total, 12 cubic yards. The cost of removing the clay would be $7.50. The heater and steam pump being small, they will be set on small brick foundations starting at the floor level, and will cost, say, $9.

The concrete for the engine and boiler foundations can be made of broken stone, or broken brick if stone cannot be had, although the writer prefers stone. It should be broken to about egg size and well set before the sand-and-cement mortar is mixed with it. The sand and cement should be mixed dry. The concrete should be laid about 6 inches deep in the excavation and should be rammed down well; then another course should be added, when the boiler-wall foundation is or should be within 6 inches of the earth level, making the concrete 12 inches thick, the excavation being 18 inches deep, except under the bridge wall, which starts at the surface. The proportions for the concrete should be one part cement, two parts sharp sand and four to five parts broken stone.

The concrete for the engine foundation should be placed at the same time the boiler foundation is laid, and it will be similar to it, except that not more than four parts of stone should be used, and portland cement will be insisted upon. The concrete foundation for the engine will be 18 inches deep, the excavation being 5 feet deep, thus allowing 18 inches for the concrete and 5 feet of brick up to the sub-base of the engine.

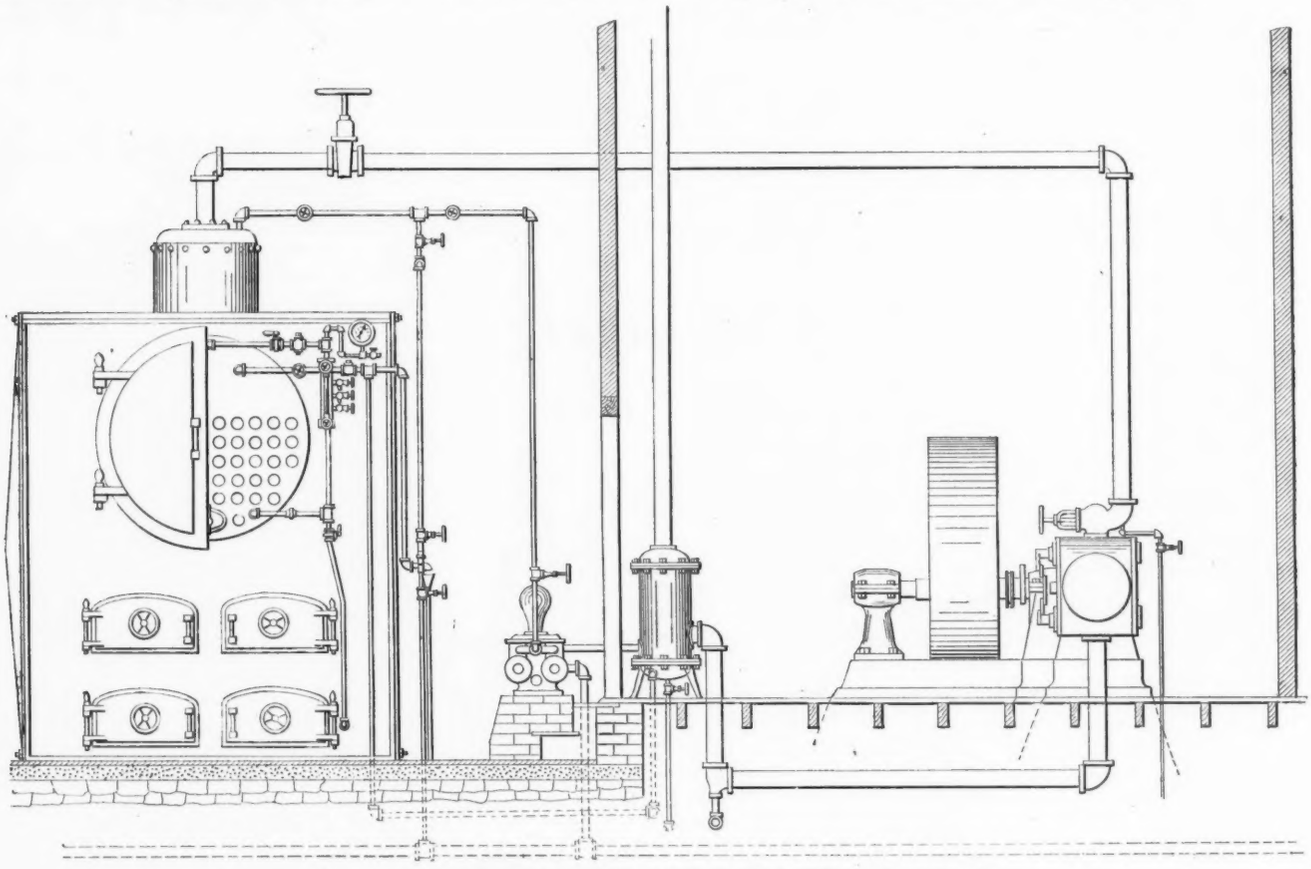


FIG. 1. LAYOUT OF STEAM POWER PLANT OF 100 HORSE-POWER CAPACITY

The concrete being in place, and having used 3 cubic yards, which has cost: for broken stone, $1.25 per cubic yard, or $3.75; 30 bushels of sand, at 10 cents per bushel, $3; 5 barrels of cement, at $2 per barrel, $10, and including one day's time put in by the "working foreman," labor cost and expenses, a grand total of $25.50.

Building the Boiler Setting

The boiler is now to be placed in position ready to brick. This will require the services of six laborers at $1.25 per day of 10 hours, and it will take 2 days, which will cost $15. The foreman's pay will amount to $9; rent on timbers, which will have to be leased, $2.50. The side track being alongside the plant, it is not neces-

sary to haul the boiler. The brickwork will be let out at $3 per thousand, the material being furnished by the owner. The setting takes 16,000 common red brick, which will cost $48 for laying alone; the fire brick will cost $12 per thousand to lay, as the specifications call for this to be "special." Every three courses in hight in the side walls is to be a header, run as shown in Fig. 3. This method prevents the walls from falling in or shelling off, as they are apt to do when laid in the ordinary way. The front arches are to be made self-supporting, brick to brick. This does not require the support of liners. The writer has had arches built in this manner which withstood 18 months of hard usage and burned out several sets of liners. The cost of laying the 2500 fire-brick is $30. All brickwork is done in accordance with the blueprint showing the boiler setting. The 16,000 red brick cost by the carload $10 per thousand, or $160. In the boiler setting the fire-brick cost $19 per thousand, being of a good grade, making a total of $47.50 for the fire-brick. The 160 bushels of sharp sand needed costs 10 cents per bushel, making the total cost of sand for the boiler setting $16; 20 barrels of good cement at $2 per barrel, $40; 800 pounds of fire-clay, or practically 3 barrels, at $1 per barrel, $3; 8 barrels of lime at 90 cents per barrel, $7.20; two helpers with the bricklayer, at $1.25 per day each for 20 days, $50. The sand, lime, brick and cement are delivered on the side track at the plant. As enough brick will be purchased for the whole plant, a fair price and rate can be obtained.

Six laborers will be needed to raise the stack, which can be done in one day, and $6 must be paid for the gin pole, which will have to go against the cost of the plant. The foreman's time amounts to $4.50, and labor $7.50. Four days' time of the foreman will have to be charged to the boiler setting, which will amount to $18. As the engine foundation is laid first so it can be "setting," the foreman can be adjusting his engine, fitting piping, etc., during the 20 days required for setting the boiler. A handy man to assist the foreman costs $1.80 a day, and for the full time amounts to $14.40. This will have to be split up between the engine- and boiler-room charges; 16 days of the foreman's time can be fairly charged to the engine room, fitting up the heater, pumps, etc. The pump charge is against the boiler room, of course. The foreman's time up to the starting of the engine, not including the first few days, which have been accounted for, amounts to $72. He will run the plant a week for testing purposes, but is paid for this week at the same rate; therefore, this does not come against the real cost of the plant.

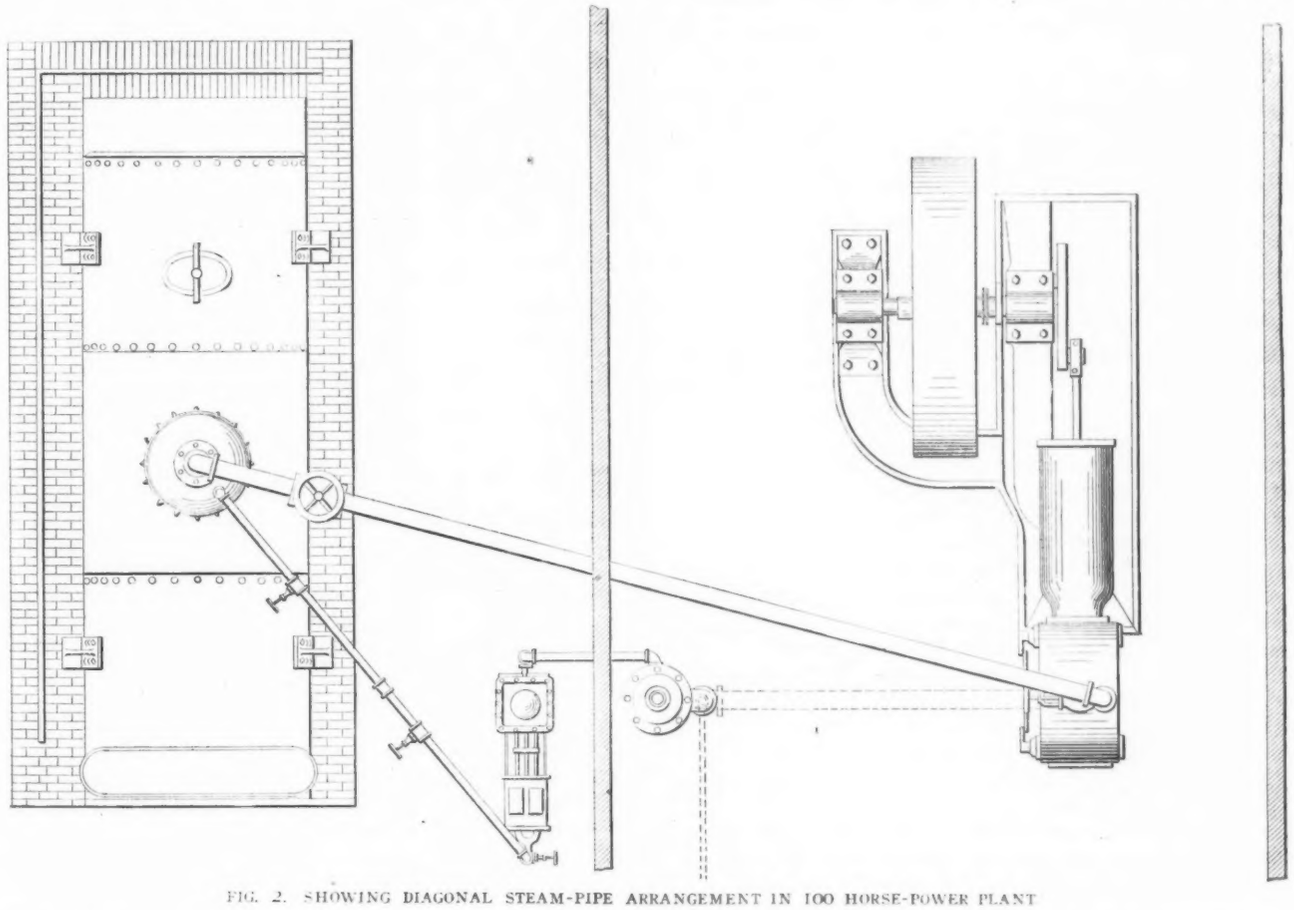


FIG. 2. SHOWING DIAGONAL STEAM-PIPE ARRANGEMENT IN 100 HORSE-POWER PLANT

Placing the Engine on Its Foundation

As a great many readers will be interested in the smaller details of building such a plant, I will start at this point with a close description of how and why such and such things are done. First, in placing the engine on the foundation, two timbers, 4 inches thick, are placed on each side of the foundation so as to catch the weight of the engine, and allow rollers to move over the bolts without striking them. The engine is pulled up from the end of the foundation on two skids. The foundation bolts are properly set by a templet made of ⅞-inch boards nailed together with the center line in alinement with the center line of the fly-wheel. These measurements are taken from the blueprint furnished by the engine builders. When the templet is square and level, the foundation bolts, which are 1⅛ inches in diameter, are put in place. Some wooden boxes, 2 inches square inside measurement, are placed around these bolts, so that when the brickwork is done it will not prevent the swinging of the bolts a little. The bolt washers are made so that the bolt head cannot turn.

The center line is located in accordance with the electricians' plans, so as to bring the pulley on the dynamo in line with the engine pulley. This is one of the first steps but one of importance, as the writer once saw an engine jacked around on the foundation, which caused trouble all the time. The bolts are all made even on top, and templet level, each one having a 7x7x¾-inch cast-plate on top. After trying the templet the second time, the

foundation is built up to within 2½ inches of the top of the bolts. Then the top of the foundation is leveled with good strong cement mortar made of one part clean, sharp sand, and one part cement. For four days this is allowed to set, during which time the fitting and boiler setting may be carried on. Some iron wedges about ⅜ inch thick on the end are driven around under the engine bed until all is level. The spirit level is placed on the guides and across the main bearing, to be sure all is right. Then a little mud dam is built around the engine surface, and good, strong cement run under the entire engine base. The cement will soon be hard enough to remove the clay dam, and it can then be finished up nicely on top. In fact, it pays to plaster the portion of the foundation that reaches through the floor and give it a coat of paint, so that waste and oil will not catch, as it does on a rough wall. The finish-cap nuts are put on, and the engine bolted down. The main shaft is put in and a line run through the cylinder, to see that all is O. K. Then covering the engine up with a piece of old canvas, the steam piping can be begun.

Description of the Engine

First, though, a brief description of the engine may not be amiss. As stated, it is a four-valve Corliss, as shown in Fig. 1. The cylinder is 12-inch, by 22-inch stroke; speed, 165 revolutions per minute. It has two eccentrics, one shifting and the other fixed. The latter controls the exhaust valves and the former controls the steam valves through the medium of a shaft governor. By this arrangement the release and compression are kept constant and the point of cut-off can be varied to suit the load. The main bearings are self-oiling, the piston speed is well up and the steam clearance is very low, which will help to account for the performance given later.

The steam pipe is short, say, so no expansion joint is used, and anyway it is desirable to do away with as many fittings and turnings as possible. The main steam pipe is 4½ inches in diameter, with one ell which cost 55 cents; the exhaust line is 6 inches in diameter and runs to the inclosed heater, which is placed close to the engine, or between the engine and boiler. The exhaust enters the side of the heater and goes out at the top, thus requiring three ells, at 80 cents each, in the exhaust pipe. The Berryman heater with seamless brass return tubes is 68 inches high and 18 inches in diameter, with a settling chamber. The cost of this heater is $106, erected. A 1-inch drain pipe is tapped into the exhaust pipe to the heater, to drain in cold weather. The boiler feed-pump is one of the duplex type and costs erected, including fittings, $60. The supplementary injector is furnished by the boiler manufacturer, so it is included in the price of the boiler.

The cost of the boiler, delivered 350 miles from the factory, is $700. It has the following dimensions: Diameter, 66 inches; length, 16 feet; shell, ⅜ inch; heads, ½ inch. There are 54 four-inch tubes and the dome on the boiler is 34x34 inches; also, full flush-front Tupper grate bars, a 5-inch safety valve, 8-inch steam-gage combination and a water column of best design. The smoke stack is of No. 10 steel, 32 inches in diameter, 45 feet high. The boiler is made according to Hartford specifications and is covered by a Hartford insurance policy for $400, for one year.

Detailed Cost of Piping

The cost of the piping, etc., is as follows: Twenty-three feet of 4½-inch steam pipe at 35 cents per foot, $8.05; one 4½-inch ell, 55 cents; covering for this pipe, $10; 16 feet of 6-inch exhaust pipe through the heater at 50 cents per foot, $8; 3 ells at 50 cents each, $1.50; three 6-inch ells, $2.40; 100 feet of ¾-inch pipe at 3½ cents per foot, $3.50; twenty ¾-inch ells at 5 cents each, $1; 50 feet of 1-inch pipe at 5 cents per foot, $2.50; 8 ells, 40 cents; 20 feet of 1½-inch pipe at 6 cents, $1.20; 2 ells (1 a tee), 18 cents. There will be a few feet of pipe left over, as well as a few ells, but this may be put into the cost of the plant, as they will come in handy. Jenkins valves are used, as they can be repaired in place.

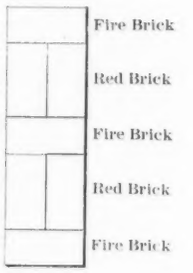


FIG. 3

Following a brief description of the pipe lines I will tell how our plant ran with the diagonal steam pipe, shown in Fig. 2, using one ell. This pipe was covered. The exhaust pipe ran from the side of the engine down and up to the side inlet to the heater, and then straight through the roof of the building. The water circulation is through the closed heater, thence into the boiler. There is a 1½-inch globe valve between the boiler and the check valve, so if there should be any trouble with the check we could cut the check off and work on the boiler. This plant was not built for show, but to operate economically. It possibly would be well in some cases to use a 72-inch boiler, giving 125 horse-power, which would add $150 to the expense of the plant; likewise to put in a good steam separator, which would cost $56.

The last articles furnished were a Phœnix oil separator, a set of wrenches and engine oil set, costing $15, $4 and $3.50, respectively, making the total cost of the plant $3102.28. The cost of the engine was $1580, delivered; foundations, $434.60; erection, $141.40; fittings, $60.28; heater, pump, engine and boiler, $2446. There was also a charge of $20 for small tools used about the plant.

The following statistics of operation of a plant are from active practice: The engineer does his own firing and looks after the plant, for $65 per month. It will be necessary to mention that the plant runs a Warren induction-type dynamo, belted. As it has been demonstrated that this size dynamo takes 2½ horse-power to carry the rotor and exciter, the following supplies will be needed for a month's run of the steam plant: Cylinder-oil, 5½ gallons, at 35 cents per gallon, $1.92½; engine oil, 4 gallons at 25 cents, $1; waste, 5 pounds at 9 cents per pound, 45 cents.

In the following table are given the ampere loads at the switchboard. It is necessary to take this into consideration, as a varying load uses more fuel:

P. M.....	4:30	5:30	6:30	7:30	8:30	9:30	10:30	11:30			
Amperes...	13	18	19	20	18½	14	12	10¼			
A. M....	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:00		
Amper's	10	10	10	10	10	11½	14	11	10		

The run is 16½ hours for the month (December). The shortest run is in June, 9 hours, so the average would be 12¾ hours.

The average horse-power at the switchboard is 39.57 for December. To this will have to be added 20 per cent. for belt transmission, 2 per cent. for friction, and, as stated, 2½ horse-power for the exciting current, which makes 50.97 horse-power, or 51 horse-power in round numbers. Assuming 3 pounds of coal per horse-power-hour, $51 \times 3 = 153$ pounds per hour, and this for 16½ hours equals 2524 pounds, which, taken from the 3000 pounds allowed for the run, leaves 476 pounds. This is used in raising steam. As the boiler described always has 60 pounds of steam on in December and coal in this region costs 6½ cents per bushel (practically 80 pounds), the cost for 3000 pounds is $2.40; for 30 days in a month it would be $72. This makes the month's expenses for power delivered $140.38, and, allowing 10 per cent. for depreciation on the plant, gives $140.38 + $26 = $166.38. This is taken from the total cost of the plant. Note also that the greatest load is 59 horse-power at the switchboard, or 75 indicated horse-power, and it falls as low as 39 horse-power; but this is true of all small plants, and for this reason it requires more coal than a steady load. We carry 100 pounds of steam under full load, but it is allowed to drop on light loads, which does not make for the best economy.

Elimination of Friction in Ball Bearings

Importance of This Question in View of the Application of Such Bearings in Heavy Work; Sources of Friction Analyzed

BY J. F. SPRINGER

The elimination of friction from bearings in general is one of the most important topics that can engage the attention of the mechanical engineer. There are three main reasons for this: First, friction means abrasion of material, and the removal of material through abrasion is a

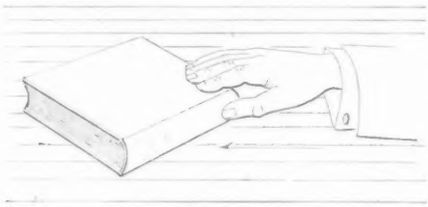


FIG. 1

very great disadvantage, inasmuch as it results in change of form and dimensions of the contacting parts, thus limiting their life. This is what we term "wear and tear." Second, the wearing away of this material requires power, and this power is worse than lost. And in the third place, friction sets up heat, which alone is often a most serious detriment.

Friction is of two kinds—*sliding friction* and *rolling friction*. Given two surfaces in contact, if there is such motion of one relatively to the other that the motion is parallel to the contacting surfaces, the result is sliding friction. Thus, as in Fig. 1, a book pushed across the surface of a table gives an example of sliding friction. And, furthermore, it is immaterial whether the book is pushed in a "right" line. Indeed (Fig. 2), it may be rotated so that every point of the surface of the book contacting with the table surface, except the center of rotation, moves in a circle, yet sliding friction results if these circles are in a plane parallel to the

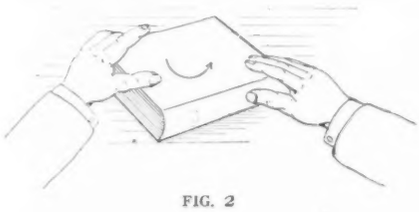


FIG. 2

surface of the table. Such friction arises, of course, because the contacting surfaces are not absolutely smooth and so present to each other irregularities which mutually engage. When motion occurs under pressure these mutually engaging projections tend to abrade each other (Fig. 3). This is because the pressure, in proportion to its amount, tends to maintain the interlock. As stated, the removal of the particles is wear, requires power and sets up heat. Thus is to be explained the excessive wear, loss of power and rise of temperature which occur in the ordinary plain bearing.

However, the motion may not be in a direction parallel to the contacting surfaces, but may be such that there is an introduction and withdrawal of small projections, and this constitutes a form of rolling friction. It is due to the fact that the contacting surfaces are not absolutely smooth, but present to each other slight protuberances and depressions at a time when contact is maintained under pressure (see Fig. 4), as is the case with a wheel. Then there is the continual presentation of limited contact, combined with pressure, whether that which rolls is a ball or a roller. If the particles in actual contact are not adequately supported by others in their vicin-

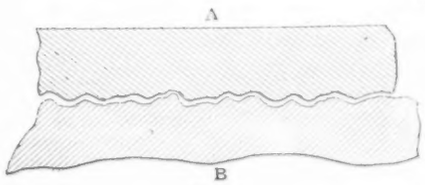


FIG. 3

ity, small particles are detached from both contacting surfaces by a crushing process. Hardness combined with toughness (which it is now possible to secure), goes far to eliminate this particular result of rolling friction. But the difference between sliding and rolling friction, as to abrading result, is well known to be very great. Indeed, a mechanical engineer has achieved a tremendous practical result when he has succeeded in exchanging a sliding contact for a rolling one.

In this article it is proposed to deal with the elimination of friction from ball bearings. This is a matter of great practical importance for the reason that ball bearings are no longer merely the "playthings" of the mechanical engineer. They are, of course, still used in electric fans, carpet sweepers and baby carriages, as there is no doubt of their suitability for these purposes; but they are being increasingly applied to heavy service, and the making of balls has greatly progressed, one at least of our manufacturing companies making and listing steel balls as large as 4 inches in diameter. Ball bearings are being applied to uses where the loads run to twenty-five and fifty tons. They are here to stay, because when constructed in accordance with de-

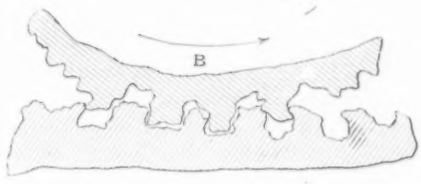


FIG. 4

signs available, with the accuracy possible, and with the steels obtainable, they are capable of tremendously exacting service. The experimental stage is rapidly being passed.

Sources of Friction in Ball Bearings

There are at least four sources of friction in ball bearings. I enumerate them thus: (1) Rolling friction, arising from the fact that the parts in rolling contact are not absolutely smooth surfaces, and also from the circumstance that contact is so limited; (2) sliding friction, arising from the contact of balls with balls; (3) in four-point bearings, the conflict of the axis of rotation set up by the inner raceway with the axis of rotation set up by the outer raceway; (4) friction arising out of the surface-grind set up through compression between the ball and the bearing surface at a time when this surface is not parallel with the instantaneous axis of rotation of the ball.

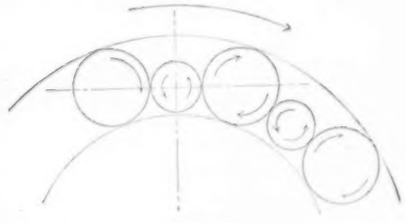


FIG. 5

The first source of friction—that is, the friction arising from rolling contact—is largely eliminated by increasing the hardness and smoothness of the balls and raceways. The second source of friction—that which arises from the sliding contact of balls with balls—has attracted the at-

tention of many inventors. The point should be emphasized that this friction is a "sliding" and not a rolling one. A little attention to the subject will convince one that the balls are rotating in opposite directions at the point of their mutual contact. It would seem that the only effective means of eliminating this source of sliding friction is the introduction of a ball or roller, or the equivalent, between consecutive bearing balls in such a manner that the separating means is not in pressure contact with either raceway. See Fig. 5. A separating device which does not roll would have but little effect, apparently, as the slide would still remain. It is not the writer's purpose to treat of the two preceding sources of friction in detail, but to devote the most attention to the third and fourth sources. Taking up the source of friction to which four-point bearings are subject, and which consists in the

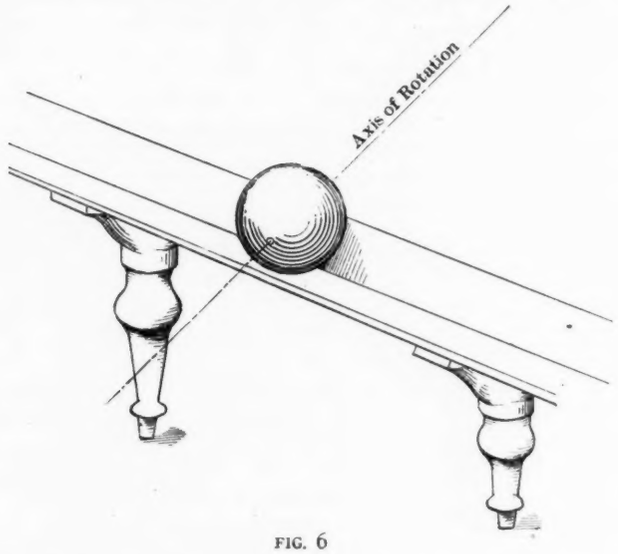


FIG. 6

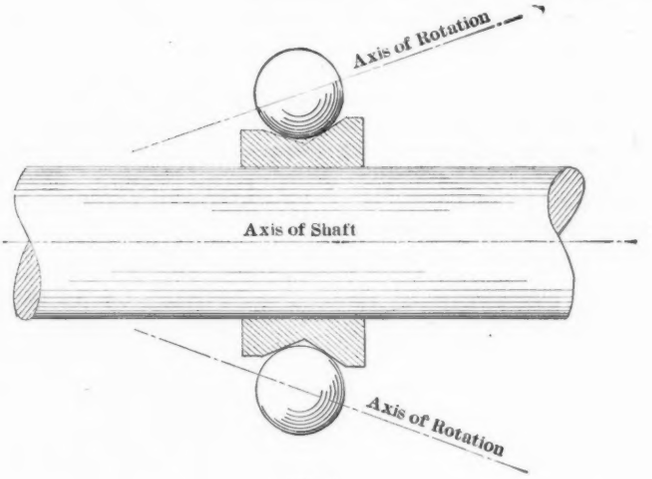


FIG. 7

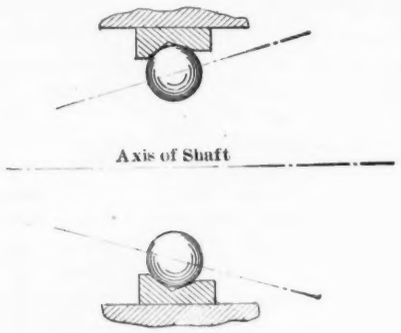


FIG. 8

CONFLICT OF THE AXES OF ROTATION, a little consideration will convince one that when a ball is rolled in a V-shaped groove an axis of rotation is set up. That is to say, two surfaces of contact are sufficient to determine an axis of rotation. An example of this is seen when a ten-pin ball is rolled in the return trough, Fig. 6. Here an axis of rotation is immediately set up. Now this same thing is true whether the ball is rolled along a straight groove, as in the example just cited, or whether the ball is rolled in a circular groove. At every instant it has a certain definite axis upon which at that instant it may be regarded as rotating. Such a definite axis of rotation is set up by a V-shaped groove on a shaft, Fig. 7, and also a definite axis of rotation is set up independently by the V-shaped groove in the housing, Fig. 8. In a four-point bearing these two V-shaped grooves exist simultaneously. And so in consequence there result simultaneously the efforts of the two grooves each to set up its respective axis of ball rotation. It becomes, then, a matter of considerable importance that these two axes of rotation shall in reality not be two but one single axis. That is to say, it is important that the axes should coincide (Fig. 9). Otherwise there is a contest between the two separate axes, which will give rise to a sliding friction.

HOW TO FIND THE AXIS OF ROTATION

It will be instructive to point out how the axis of rotation set up by the contacting surfaces of a V-shaped groove may be found practically. By referring to Figs. 10 and 11 it will be seen that the ball *A* contacts with the bearing ring at the points *1* and *2*, Fig. 10, and at the points *5* and *6*, Fig. 11. Draw a straight line through *1* and *2*, or through *5* and *6*, and prolong it until it intersects the axis of the bearing at *3*. Draw a straight line through *3* and the center of the ball *4*. This line *3—4* is the axis of rotation. It will readily be seen that in order to avoid conflict of the axes when *both* inner and outer V-shaped grooves occur in one bearing it becomes necessary that the lines *1—2* and *5—6*, when prolonged, shall meet the axis of the bearing at the one point *3*. Fig. 12.

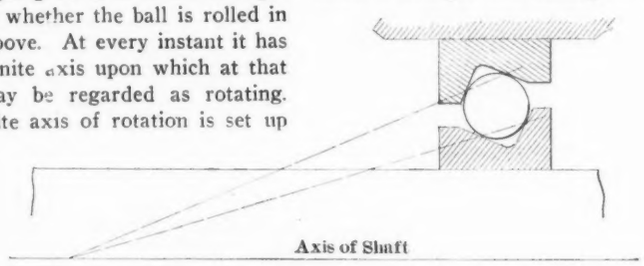


FIG. 9

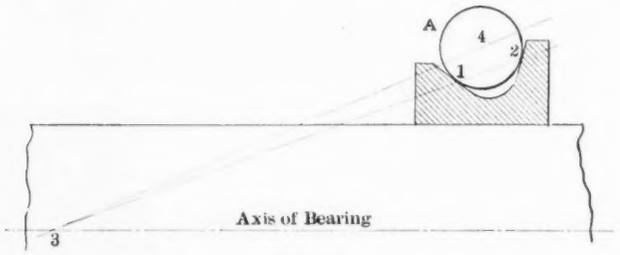


FIG. 10

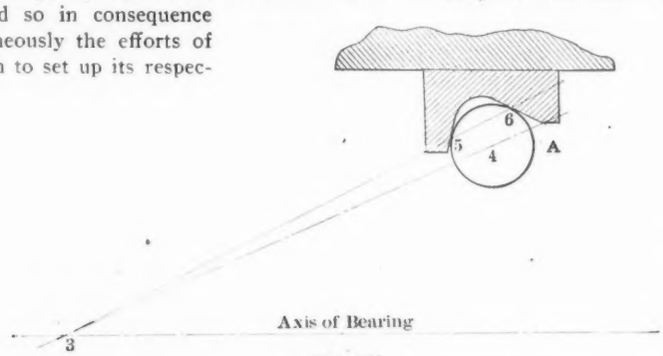


FIG. 11

Some years ago this matter was dealt with in effect by an Italian inventor named Casalegno. He seemed to think that when he got the lines *1—2* and *5—6* to intersect the axis of the shaft at the same point he had eliminated all sliding friction—at least, all sliding friction due to contact of balls with rings. He was in error as to this, as will appear in the sequel.

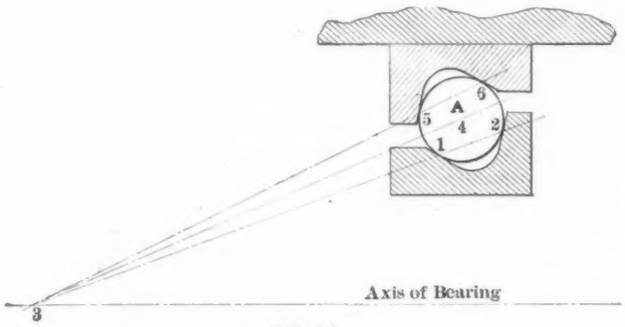


FIG. 12

Before passing on to the next source of friction it will be instructive to call attention to an unnecessary restriction to which this same inventor thought it necessary to subject the three-point construction. He thought that when one of the bearing rings presented a single surface to the ball instead of a V-shaped groove, the prolongation of this single surface should pass through the point *3*, Fig. 13. In this he was mistaken, in so far as the harmonization of velocities is concerned, for the following reason: *One* point of contact between a surface and a rolling ball is not of itself sufficient to determine a definite axis of rotation. In fact, it harmonizes with any axis whatsoever. If one of the bearing rings, say the inner, has two points of contact with the ball, Fig. 14, and consequently determines a definite axis of rotation, the one point of contact between the outer ring and the ball will not set up an additional axis, but will accommodate itself to the one set up by the inner ring. And it does not matter where this point of contact of the outer ring is situated. The restriction that it should be so located that the tangent at this point would pass through *3* is unnecessary. In three-point bearings, then, the conflict of axes which we have been considering does not occur.

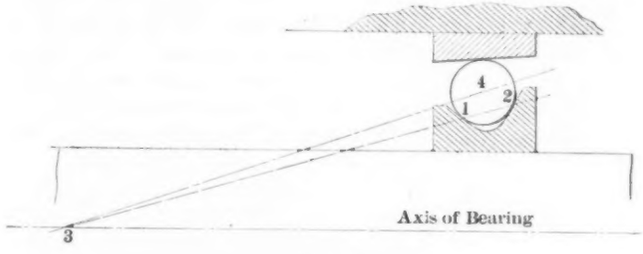


FIG. 14

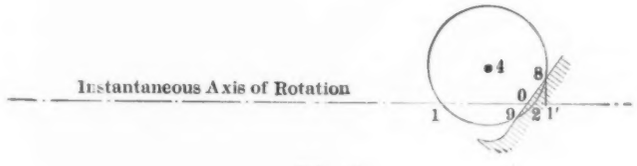


FIG. 15

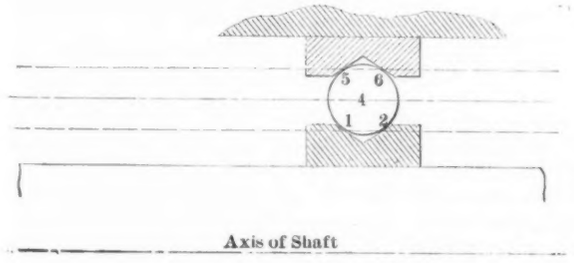


FIG. 16

THE MOST SERIOUS SOURCE OF FRICTION

Regarding the fourth source of friction—that which arises from the actual rotation of a ball relatively to the contacting surface—if steel balls and steel bearings could be made absolutely smooth and incompressible, and not subject to minute flaking arising from inadequacy of support, this trouble would not arise. As it is, however, the trouble exists and constitutes perhaps the most serious source of friction to which ball bearings are liable. By referring to Fig. 15, which shows to a greatly exaggerated degree the compression between the ball and the race, it will be noticed that the line *1—2* is not parallel to the surface of contact but makes an angle with it.

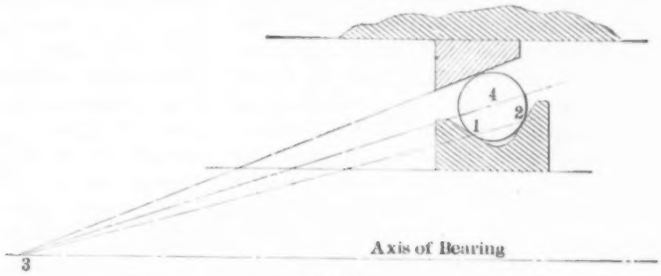


FIG. 13

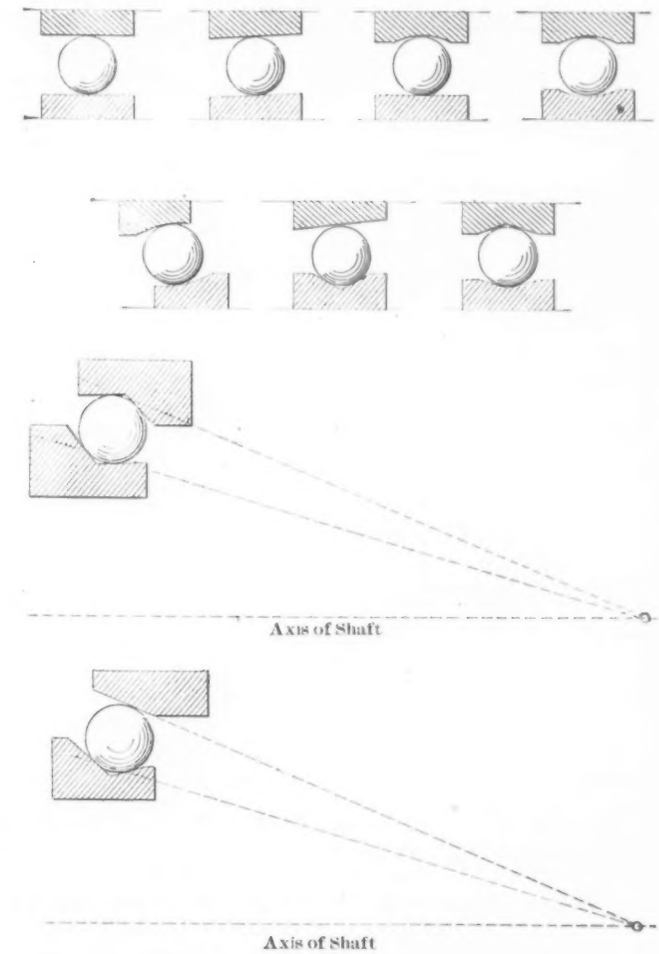


FIG. 17

In order to comprehend clearly the source of friction which the writer is

about to explain it will be necessary to understand somewhat the character of the line *1—2*. The technical name for this line is the *instantaneous axis of rotation*. Its character is this: If we take our position on the bearing ring and, disregarding its motion, pay attention only to the motion of the ball relatively to this bearing ring, we shall observe that all points on this line *1—2* are quiescent, that the ball is in fact rotating about this line as an axis. This is the reason for calling the line an axis of rotation. But this axis of rotation is good for an instant only. As the ball rolls, there is a constant change of axis. It is therefore appropriate to call it the *instantaneous* axis of rotation, seeing that it is the axis for the instant only.

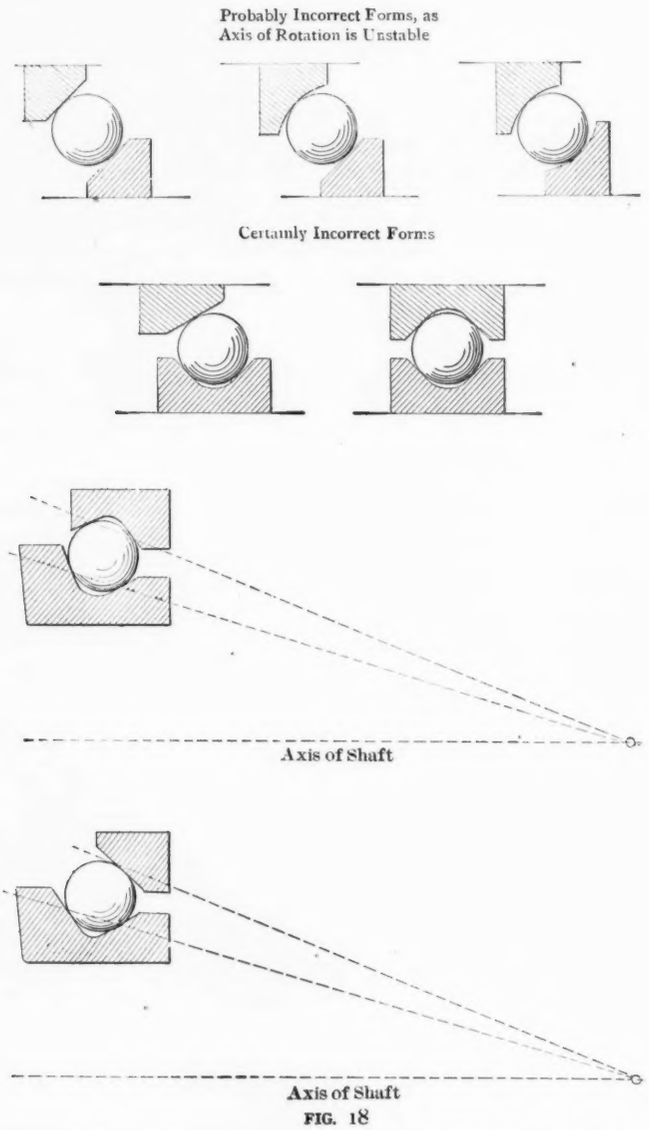


FIG. 18

This rotation of the ball relatively to the contacting surface is complicated with compression. By referring again to Fig. 15 it will be seen that all points of the line of contact *8—9*, except *0*, which is quiescent, are swinging in circles about the line *1—2*. Thus, *8* swings in a circle whose center is *1'* and whose radius is *1'—8*. That this gives rise to sliding friction is quite clear. That this friction is approximately proportional to the pressure *along* *1—2* would seem to follow as a consequence. It will be readily granted by those who have followed this discussion that here is a most serious source of sliding friction. It will be observed, however, that it disappears as the angle between *1—2* and *8—9* is diminished. It becomes very important, then, from the point of view of the elimination of this source of friction, that this angle should be made as small as possible. The result of all this is that *flat* raceways are an absolute requirement. By *flat raceways* is meant raceways whose sides are parallel, or approximately so, to the corresponding instantaneous axis of rotation. Examples of such raceways are shown in Fig. 17. In contrast with these are shown in Fig. 18 examples of more or less incorrect forms of raceway.

In applying these principles to the special cases where one instantaneous axis of rotation is parallel to the axis of the shaft, let it be noticed that this will have the effect of carrying the point *3*, where the instantaneous axis and the axis of the shaft meet, off to infinity. This will result in requiring the other instantaneous axis to be parallel to the axis of the shaft. So also with the axis of rotation itself. This is brought out in Fig. 16. In such cases it is necessary that *all* bearing surfaces should be parallel, or approximately so, with the axis of the shaft, at least at the several points of contact.

Probably the great bulk of ball bearings, if we except a few styles made in the last few years, have been constructed on more or less erroneous fundamental principles. The time is at hand when a tremendous increase in the application of ball bearings to heavy machinery is about to take place. It is therefore important that the fundamental conditions should be discovered and made known. It is hoped by the writer that the present article is a serious contribution to this difficult subject.

Catechism of Electricity—XXIV

Station Direct-current Voltmeters

492. *Wherein does a station voltmeter for measuring direct-current pressures differ from a portable direct-current voltmeter?*

The station direct-current voltmeter is a much larger instrument. Two forms are shown in Figs. 110 and 111, the former being of the illuminated dial type, and the latter of the "edgewise" pattern. The working parts of these instruments operate on the same principle as those of the portable direct-current voltmeters. As but one scale is used, there is but one resistance coil, and as the meter is intended to be permanently connected in circuit no key is provided.

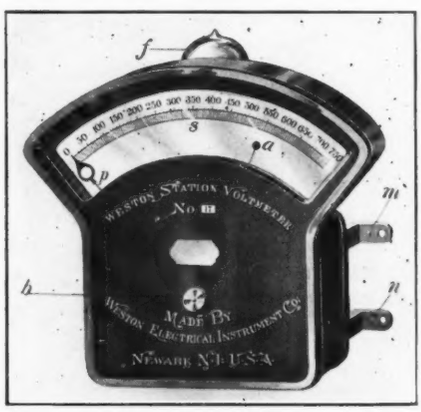


FIG. 110. ILLUMINATED DIAL STATION VOLTMETER FOR MEASURING DIRECT-CURRENT VOLTAGES

493. *Describe in detail the meter shown in Fig. 110.*

The meter in Fig. 110 carries in addition to the pointer *p*, a round index *a*. This consists of a circular disk of blackened aluminum, and its position along the

scale can be adjusted from outside of the case by turning the knob *b*. In practice, the knob is turned so that the index *a* is directly below the point of normal voltage. When the pointer *p* reaches the point of normal voltage, the black disk of the normal index *a* appears in the center of the circular opening of the pointer, a narrow ring of white around the disk being visible. By means of this simple arrangement a very small change in the

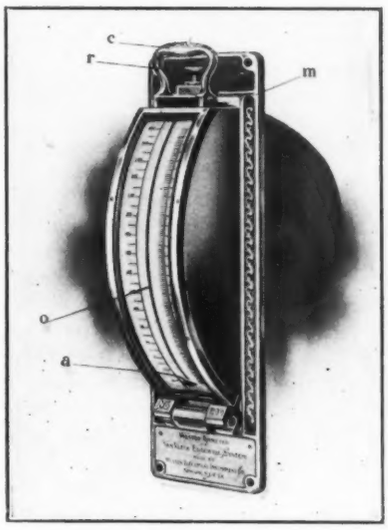


FIG. 111. EDGEWISE TYPE OF DIRECT-CURRENT STATION VOLTMETER

voltage can be seen at a considerable distance from the meter. The dial, or scale, *s* is of opal glass set in a frame at the back of the instrument. Directly behind the scale, an incandescent lamp *f* and a pair of mirrors are mounted so as to illuminate the scale uniformly from behind, thereby making the figures, lines, pointer and index distinctly visible at a distance from the instrument. Two of the iron brackets used to suspend the meter are shown at *m* and *n*. A dust-proof cast-iron case protects the working parts from injury and shields them from the disturbing influence of external magnetic fields.

494. *What are the features of the edgewise voltmeter in Fig.* 111?

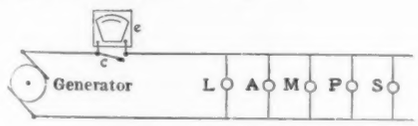


FIG. 112. SHOWING CONNECTION OF AN AMMETER IN CIRCUIT

This type is advantageous where it is necessary to mount the measuring instruments very close together, and in an elevated position. The meter is mounted by cutting out a portion of the switchboard so that the part back of the frame *m* projects through; connections are made to it from the rear. The instrument may be tilted by means of the handle *c* and held in the desired position by means of an insulated thumb screw *r*. This permits the best view of that part of the scale which is most in use. The scale of this voltmeter is not illuminated, and no normal-voltage index is provided. The moving part of the meter is connected to the pointer *a* through the slot *o*.

495. *Are multipliers used with station voltmeters?*

Yes; in the same manner as with portable voltmeters.

PORTABLE DIRECT-CURRENT AMMETERS

496. *Wherein do ammeters differ from voltmeters?*

Ammeters are instruments for measuring the strength of a current flowing through a circuit, and they are connected in series with the circuit as at *e*, Fig. 112. If the instrument is not to be used continuously, a switch should be wired in as at *c* to short-circuit the ammeter when it is not needed, in order that no current will pass through the meter, and also in order that the current in the main circuit will not be interrupted in case it becomes necessary to remove the meter. The mechanical construction of direct-current ammeters differs considerably from that of direct-current voltmeters, although the underlying principles of operation are practically the same in both cases.

497. *Show a typical form of portable direct-current ammeter.*

Fig. 113 shows an instrument complete. Except that the binding posts (*a* and *b*) are larger and there is no key nor push-button, the exterior appearance of the meter is similar to that of the portable direct-current voltmeter described last month. The large binding posts are necessary because the entire current of the circuit passes through the meter when in use, and the short-circuiting switch previously mentioned replaces the key.

498. *What is the interior construction of this type of ammeter?*

Fig. 114 indicates the construction more or less diagrammatically. The permanent horseshoe magnet *N S* the fine copper-wire coil *c*, inclosing the soft-iron core *s*, the spring *r* holding the coil in position, and the pointer *p* attached to the coil, will be recognized at once as being of the same construction and serving the same purposes as the corresponding parts in the direct-current portable voltmeter described in June. Here, however, the similarity ends. The current upon entering the meter at the binding post *a* passes to a copper plate *a'*, and from this plate passes through several resistance coils *m* and the active coil *c* to the plate *b'*, from which it passes to binding post *b*, and back to the circuit. The operation of the instrument largely depends on the resistance coils *m*, which consist of insulated wires wrapped non-inductively around the permanent magnet *N S* and form the principal conductors of the current. These coils and the movable coil *c* are all connected in parallel to the plates *a' b'*, and the resistances are so proportioned in number as to allow the coil *c* to receive the amount of current necessary to cause the proper deflection of the pointer over the scale.

499. *Can this ammeter be kept in circuit continuously?*

Not without affecting its accuracy by the heating of the resistance coils, unless the current is relatively weak. If the current is one-half or more of the full range of the instrument it should not be kept in circuit longer than three minutes. As a rule, half a minute is ample time in which to take a reading. If the meter is to be kept in circuit continuously, the current should not exceed one-quarter of

FIG. 113. A PORTABLE DIRECT-CURRENT AMMETER

the full range of the 300- and 200-scale ammeters, while with the 150-scale ammeter one-third of the full range will be the limit. The 100-scale ammeter may be kept in circuit for five minutes at three-quarters of its full range before its accuracy is impaired more than 1 per cent., and for an indefinite period at one-half range. The 50-scale ammeter may be kept in circuit indefinitely at three-quarters range without exceeding the 1 per cent. limit of inaccuracy, and the 25-, 15-, 5- and 0.75-scale ammeters at full range for an indefinite time.

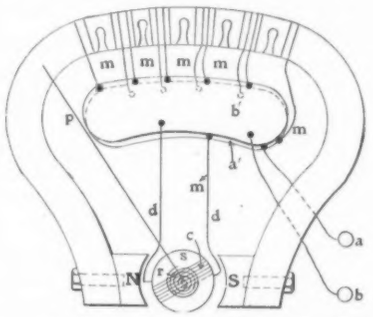


FIG. 114. SHOWING INTERIOR CONSTRUCTION OF AMMETER

500. *Are there any precautions besides those already mentioned that should be observed in using ammeters?*

An approximate idea should be had of the current in a circuit before an ammeter is connected in. The short-circuiting switch should be carefully opened the first time to show whether the current

flows through the meter in the proper direction to deflect the pointer over the scale. A slight tapping on the case of the meter will overcome the friction of the pivot and aid the pointer in coming to rest at the proper point. Ammeters should not be used near dynamos, large masses of iron, or conductors carrying large currents. The connecting wires or cables should be securely fastened to the table or bench upon which the meter is used. Care should be taken to handle ammeters carefully in order to avoid damage to their pivots or jewels. Ammeters which must be kept in circuit continuously carrying current near their maximum capacity should be connected to the circuit by large wires or cables in order that the heating at the contacts of conductors and binding posts may be kept low.

The meter should be laid approximately horizontal—not vertical nor in an inclined position, because the friction of the bearings is thereby increased and seriously affects the accuracy of the meter. If the meter is to be used for any length of time in one place it is advisable to screw it down. Brass screws should be used; iron screws must not, because they interfere with the deflections of the pointer by distorting the magnetic field. Nails must never be employed to fasten a meter in place, as the necessary hammering would almost inevitably injure the jewels, besides seriously affecting the field of the horseshoe magnet. A meter should never be used in a place hot enough to melt the paraffin insulation on its interior wires. Wiping the glass cover just before taking a reading is liable to electrify the glass and induce a change in the aluminum pointer which, being very light, may thus be attracted and cause an error in the readings.

501. *Is there any limit to the range for which an ammeter can be made?*

No; but in practice it is found expedient to use external "shunt blocks" with ammeters for measuring currents above 200 or 300 amperes.

502. *What is a shunt block and how is it used?*

Fig. 115 shows an ammeter shunt. It consists of a number of metal strips *d*, the two ends of each strip being fitted into grooves in two brass or copper blocks *r* and *s*. Each of these blocks is provided with large and small clamping screws *a* and *b*, and *a'* and *b'* respectively, the former for connecting the shunt block in the circuit in which it is desired to measure the current and the latter for connecting the wire leads *c* to the meter.

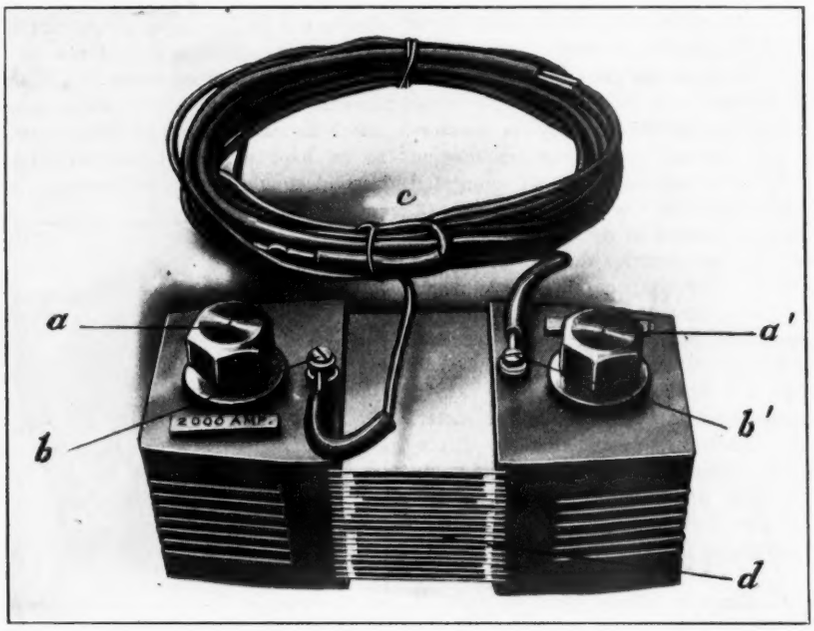


FIG. 115. AMMETER SHUNT USED IN MEASURING LARGE CURRENTS

Most of the current passes through the shunt block but a small part is "shunted" through the meter, and as this small portion varies exactly in proportion to the variations of the main current the ammeter needle responds correctly.

503. *Is the ammeter used with shunt the same as the one used alone?*

No; the meter used in connection with shunt is practically a low-reading voltmeter, with a low-resistance moving coil instead of one of high resistance. Its scale is marked in amperes, however, and so laid out that when any certain number of amperes is passing in the main circuit, the needle points to that number on the scale, although that current is not actually flowing through the instrument.

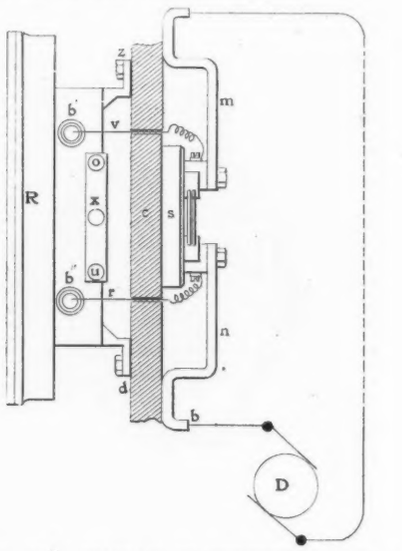


FIG. 118. DIAGRAM OF CONNECTIONS FOR A STATION AMMETER AND ITS SHUNT ON THE SWITCHBOARD

504. *Why is the shunt block made up of strips?*

In order to obtain a large radiating surface and thereby prevent heating, which would alter the resistance and make the ammeter readings inaccurate.

505. *Are any special precautions necessary in the use of a shunted ammeter?*

Care must be taken never to allow the full current of a circuit to pass directly through the meter, for it requires less than one-tenth of an ampere to give a full scale deflection.

FIG. 116

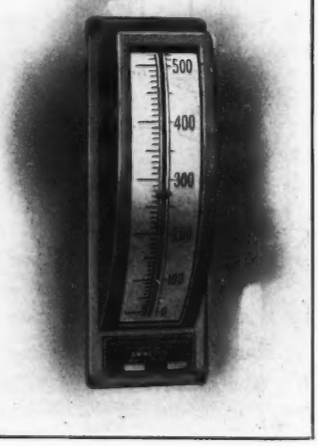


FIG. 117

STATION DIRECT-CURRENT AMMETERS

506. *Illustrate and describe some common forms of direct-current ammeters for station use.*

Fig. 116 shows a station direct-current ammeter of the illuminated dial type, and Fig. 117 illustrates the edgewise type. Both are designed for use with shunts, and are constructed on the principle described in answer to Question 503. The working parts are entirely inclosed in iron cases to protect them from dust and external magnetic fields.

507. *How are a station ammeter and its shunt connected in circuit at the switchboard?*

Fig. 118 is a diagram of the wiring, in which *a* and *b* represent the connections to the outside circuit; *D*, the dynamo supplying the current; *s*, the ammeter shunt; *R*, the ammeter, and *c*, the switchboard. The shunt should be placed at a greater distance from the ammeter than the diagram indicates; the farther away the better on account of its magnetic effect. Connection with the shunt is made by means of thick copper bars *m* and *n*. The small lead-wires *r* and *v* from the shunt are connected to the binding posts *b'* and *b''* at the back of the meter, where also the socket *x* for the electric incandescent lamp which illuminates the scale is placed; *u* and *o* are binding-posts for the lamp circuit.

Corrosion of Steel Boiler Tubes on Vessels Fitted with Turbine Engines

In the February issue of the Journal of the American Society of Naval Engineers, Commander J. Edward Palmer, U. S. N., retired, describes a curious instance of corrosion in the tubes of the Mosher boilers on the steam yacht "Tarantula." The boilers were carrying steam of from 275 to 300 pounds, and were fitted with Shelby seamless steel tubes of No. 14 and No. 16 gage, the first five rows nearer the fire being of the heavier gage. After the first two months of service complaint was made that the tubes were pitting badly, and several had given out. By the end of the second season, which means after a total service of about four months, 4 tubes had given out in the forward boiler, and 21 in the after boiler, all of these being of the thinner, No. 16, gage. When the boilers were retubed a number of the tubes which had been in use were opened up from end to end, and it was found that some were practically good, others pitted at certain places, mostly near the ends, and still others more or less pitted throughout.

Composite samples of the pitted and unpitted tubes were analyzed and showed practically the same composition. It was noticeable that a brownish deposit had collected in the pitted portions of the tubes, forming little nodules over the pit. This deposit was analyzed and invariably showed copper when taken from the pitted portions, while the deposits in the unpitted tubes gave no signs of this material. The copper was found to have come over from the blades of the turbine, with which the vessel was fitted. These blades were found to be eroded by the steam impinging upon them, and the deposit between them was found to carry from 1 to 2½ per cent. of copper, while that in the mud-drum of the after boiler, at the end of the 1905 season, showed 3.6 per cent. of copper.

Scraping Out the Cylinder of a Marine Engine

An English engineer describes in a recent issue of the *Mechanical World* how he scraped the shoulders out of a large marine cylinder in which the piston did not override the counterbore. As there was no boring tackle available, and it was almost impossible to chip the obstruction or use a file to advantage, the work was accomplished by the means illustrated herewith. Fig. 1 shows the cylinder, the shoulders formed by the piston, and the general arrangement of the tools, stays, etc., used.

Fig. 2 shows the tools, which were made of ⅞-inch octagonal steel (although round would do) 4 to 5 feet long, one end being drawn out to a triangular point. Each tool had a different taper, and by this means the cut was regulated according to the angle at which the tool was held to the job.

Fig. 3 shows the tool stay *A* for working at the bottom of the cylinder. A piece

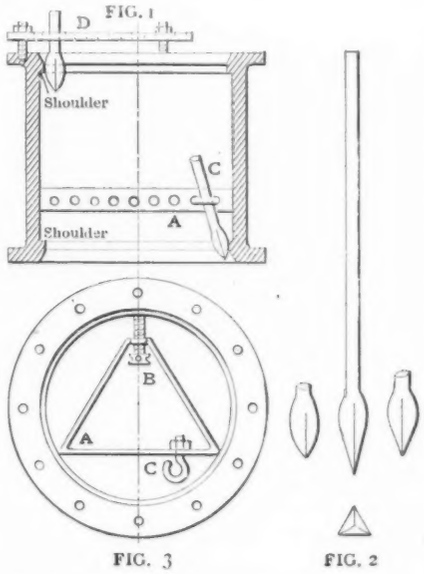


FIG. 3 FIG. 2

of 5/8x2-inch bar iron was bent into a triangle and welded, the corners being slightly rounded and one base being longer than the others. At the corner opposite the long base a hole was tapped to take a 5/8-inch pointed screw *B*. This, when screwed out, together with the two opposite corners of the triangle, press against the walls of the cylinder, forming a rigid frame. Holes were drilled round the triangle to take a hook *C* or stud as desired, against which the tool pressed when cutting (Fig. 4).

Fig. 5 shows the tool stay *D* for working at the top of the cylinder. A piece of ⅜-inch plate was cut to about a quarter circle, and about 6 inches wide. Holes were drilled to the same circle and pitch as the studs in the cylinder, and inside these again a row of holes large enough to allow the cutting tool to pass through. In some cases the plate had to be packed off the cylinder face with washers to get

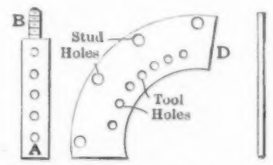


FIG. 4 FIG. 5

the correct working hight for the tool, but that would, of course, depend on the design of the cylinder, whether a deep or shallow bore. The bottom stay is easily regulated as to hight by the set-screw.

After a little practice it is surprising what an amount of metal can be removed, the long lever giving unlimited power. A heavy or finishing cut can be given as desired by using the tools with different tapers.

Spontaneous Ignition of Coal

The old hypothesis suggested by Liebig, according to which the spontaneous inflammation of coal is due to the oxidation of the pyrites, can no longer be maintained. Spontaneous ignition, according to the German scientist, Dr. Heideprim, would seem rather to be attributable to a direct oxidation of the carbon. In fact, carbon when heated has been found eagerly to absorb oxygen from the air, and this heating effect can be increased until ignition occurs. The part played by moisture in the process has not yet been determined. The physical conditions of the carbon (hardness, size, etc.) are other factors influencing the process. In connection with a recent investigation of three hundred cases of self-ignition, all kinds of mineral coal apart from anthracite were examined. In most cases the ignited coal was ordinary coal, and less frequently nut coal or coal dust. The higher the layers, the more readily will self-ignition take place. An efficient ventilation by channels in the coal layers and the thermometrical recording of temperatures by long thermometers inserted in the coal have been found to be good preventive measures, while the only available means of extinguishing such fires has been found to be a transfer of the coal and simultaneous flooding.—*The Steamship.*

The Hydraulic Elevator—VII

Further Discussion of Magnetically Operated Valves; the Double-power Hydraulic System; Otis Running-rope Method

BY WILLIAM BAXTER, JR.

As stated in the June number, magnetically operated valves have to be arranged so that they can be easily handled by persons who are not skilled elevator operators. A great many controlling devices of this kind have been invented and in the following paragraphs will be described two which are quite extensively used.

Fig. 63 is a wiring diagram of a simple controller by means of which the car can be operated from any floor of the building as well as from within the car. The controller circuit is connected with the supply wires P and N by means of a two-pole switch shown at the left side of the diagram. If this switch is closed and the controller switches are all open, as is the case when the car is not running, the current can pass from P to the wire A, then up the elevator well to the several floors of the building, and return by the wire B, passing through the door-contact switches B' at each floor, and thence to the wire B'' and to the lever of the floor switch. One of these floor switches is located at each floor from which it is desired to operate the elevator. As the floor switch is open, the current can go no farther. From the wire A it will be seen that a wire A' runs upward; this runs to a point about half way up the elevator well and there enters a flexible cable, which connects with the elevator car and reaches the up and down push-buttons; but it can pass no farther, as these push-buttons do not connect with either C'' or K'.

If a person at any floor desires to use the car, he operates the floor switch, turning it so as to set the car in motion toward that floor. Suppose the car is above him, he then turns the floor switch to the left so as to cause the car to run down. The current from B'' will pass to C', to K, to J, to and through the pair of down magnets on the valve to the wire E', and thence to the supply wire N. When the car reaches the floor, the passenger opens the floor switch, then the elevator inclosure door, and steps into the car. The opening of the inclosure door releases one of the floor-contact switches B' and thus breaks the circuit, so that the car cannot be moved until the door is closed again. After the passenger has entered the car and has closed the landing door, he can cause the car to run either up or down by simply pressing the proper push-button and keeping it pressed in until the car reaches the floor at which he desires to stop. If he desires to go down he presses the lower button, when the current passes from A' to K', thence to K and, through the route as before explained, to the wire N.

This arrangement is very simple, but has two objections, one of which is that the passenger has to hold the floor switch (or the car button) closed until the car reaches the floor, and has to use his judgment in determining just how far the car may be from the floor when he opens the switch, so that it will stop even with the landing. Another objection is that when a passenger is already in the car someone else, at one of the other floors, can interfere with its operation by turning the floor switch so as to produce the opposite movement of the car. In the same way a passenger in the car can interfere with any movement directed from a landing.

The wiring diagram Fig. 64 shows a more complicated arrangement than that just explained, but is far superior to it, as it is entirely non-interfering; and at the same time it simplifies the work of the

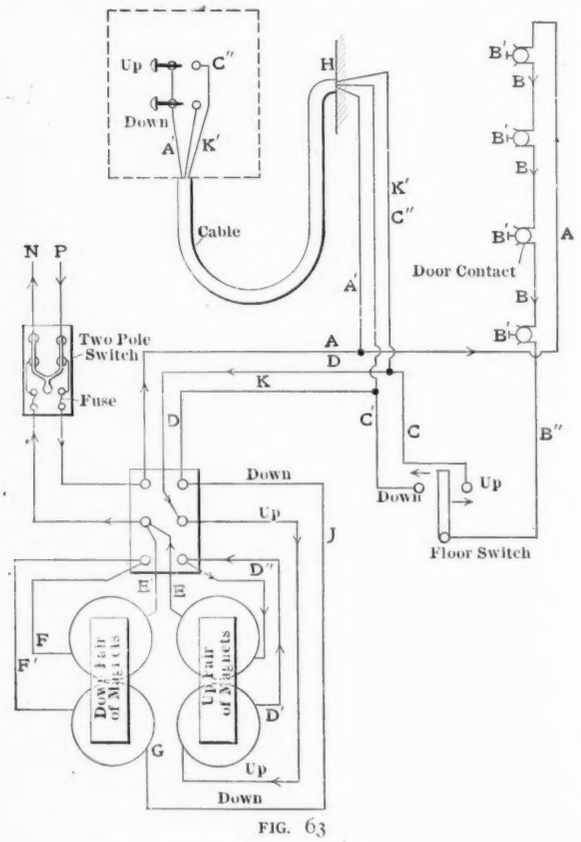


FIG. 63

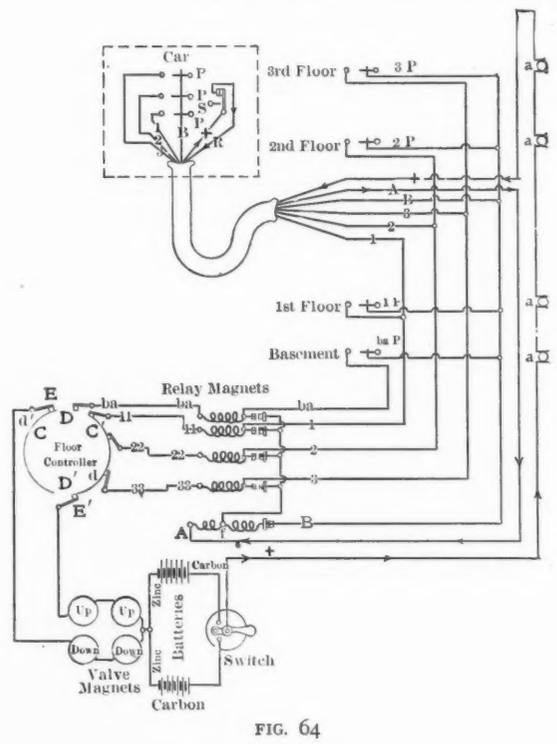


FIG. 64

passenger, for if he is at any floor and desires to use the elevator, he has only to press a button for an instant, when the car will be set in motion, whether above or below him, and will come to a stop when it is even with his floor. After entering the car and closing the landing door, all he has to do is to press, for an instant, the button corresponding with the floor to which he wishes to go, and the car will at once start off and stop automatically at that floor. The arrow heads on the lines of the diagram show how far the circuits are complete when the car is not running. The floor controller is a change-over switch arrangement, the object of which is to reverse the connections between the wires connecting with the push-buttons at the several floors and in the car, and with the brushes *E E'*, as the car passes above or below the floor; so that by means of a single button the car may be made to run down, if above the floor, or to run upward, if below the floor. The relay magnets are for the purpose of rendering it possible to keep the elevator in motion until the proper floor is reached, without having to keep the push-button depressed. It will be noticed that a wire runs from *f* up to the contacts opposite the four relays. If any one of the push-buttons is depressed, the current will flow through the corresponding relay magnet, the contacts at the right will be drawn up and a direct connection will be made with point *f*. Thus, suppose button *2 P* is pressed; the current will at once pass through the relay *22* and the contacts on the right side will be closed, so that the current may flow through from the junction point at *f*. The floor controller revolves, being driven by the elevator, and is so geared that it makes the upper end of the contact arc *C'* travel from the position in which it is drawn (when the car is at the bottom of the well) to the point *d*, when the car is at the top floor. From this it will be seen that if the button *2 P* is pressed, the car will run until the upper end of the contact curve *C'* passes from under the brush *22*; then the car will stop, and it will be even with the second floor.

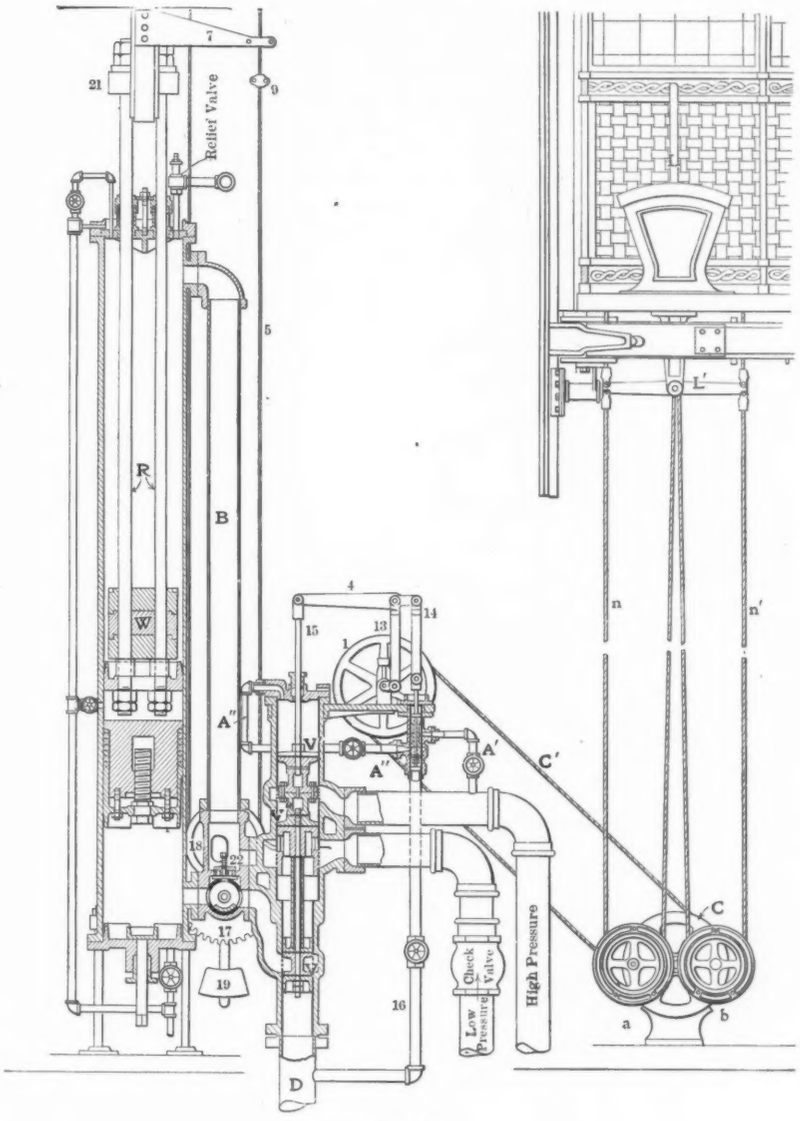


FIG. 65

The two coils between the wires *A* and *B* form a differentially wound magnet which exerts no effort when the current passes through both coils, and hence does not draw apart the contacts at the right side; but if one of the buttons is pressed, the instant the circuit from the junction *f* through the relay is closed, the right-side coil of the differential magnet becomes inactive, and then the switch contacts are drawn apart and no current can pass to the wire *B*, so that after this time it makes no difference how much the push-buttons may be manipulated, they can have no effect upon the running of the car. The circles *a a a a* represent inclosure-door switches at the landings, the same as in Fig. 63, which are provided as safety devices to prevent absent-minded persons from moving the car away from the landing without first closing the door.

While Fig. 64 is shown arranged to be operated by a battery, Fig. 63 is connected with supply wires, which may create the impression that it is for use in cases where the current is derived from a lighting circuit. As a matter of fact, however, both arrangements can be used with current derived from any source, providing it is not alternating current; for the latter, slight modifications are made.

An examination of the wiring diagrams Figs. 63 and 64, as well as the drawings 53 and 57 (reproduced in the June number), will show at once that these magnetic valve-operating devices open the valve wide to set the car in motion, and close it entirely in one movement when the car is to be stopped. The person operating the elevator cannot in any way vary the running speed, nor can he cause the car to get under headway either quickly or gradually at will, nor make a quick stop or a slow one; all he can do is to open the valve to start, and close it to stop. The speed the car will take will depend entirely upon the way in which the valves are adjusted, and this is true as to the rate of acceleration in starting and of retardation in stopping. This lack of flexibility is the reason why magnetic valve-control has not come into general use for passenger elevators. Some magnet controllers have been devised that partially accomplish the results obtained with the mechanical devices, but they are complicated and cannot be regarded as entirely practical.

Double-power Hydraulic System

In the February article of this series was presented a diagram illustrating the double-power system of hydraulic elevators, an arrangement devised to reduce the power consumption, and make it more nearly proportional to the actual amount of work done. With a steam or electrically driven elevator, the power required is directly proportional to the load lifted, and it cannot very well be otherwise; in other words, it is "the nature of the beast" to put forth an effort equal to the work it has to do and no more.

With hydraulic elevators this is not the case, for the simple reason that to run the elevator car from the bottom to the top of the building requires one cylinder full of water, regardless of whether the car is empty or fully loaded. The lifting capacity, however, must be sufficient to run the car up with the maximum load, and this means that the pressure maintained in the pressure tank must be high enough to do this maximum work. This being the case, all the water pumped into the tank must be forced against a pressure great enough to elevate the car when fully loaded. It may be asked, where does the power go to when the car is run up light, since the lifting capacity of the piston is sufficient to raise the maximum load? The answer is simply that generally the surplus power is absorbed in forcing the water at a high velocity through the contracted opening in the operating valve, the latter not being opened wide under such conditions. If the valve should be opened wide the car will run at a higher speed than when loaded, and then the surplus power will be absorbed in forcing the water through the piping, as well as the valve, at an increased velocity. As it is contrary to the nature of the hydraulic elevator to use energy in proportion to the work done, special arrangements have to be devised to accomplish the result, and although these arrangements do not accomplish it perfectly, they do it well enough to be of decidedly practical value.

The Otis double-power vertical elevator is illustrated in Fig. 65. The valves are shown in the stop position. An inspection of the drawing will show that the main valve and valve chamber are longer than the low-pressure valves described in previous articles, and in addition there is an extra valve piston V^2. The upper outlet port of the chamber connects with the lower end of the circulating pipe, and the lower outlet port connects with the bottom of the cylinder. The valve chamber is made longer so as to provide space for the port of the high-pressure pipe, and the valve is made with the additional piston V^2, so that when the valve is in the position shown, or lower down, the high-pressure water may not be able to pass into the cylinder.

The operation of this system on the downward trip of the car (up stroke of the piston) is the same as that of the low-pressure machine, that is, the main valve is depressed so as to uncover the port connecting with the lower end of the cylinder, and then the water above the piston passes down through the circulating pipe, through the valve chamber to the under side of the piston, and the latter ascends in the cylinder. On the up trip of the car, the main valve is raised until the port connecting with the lower end of the cylinder is uncovered partly or in whole, according to the speed required, and then the water under the piston escapes into the discharge pipe D and pressure water from the low-pressure pipe passes through the valve into the circulating pipe and to the upper end of the cylinder, thus forcing the piston down. If the load is less than one-half the maximum, the valve will not have to be raised any farther than is necessary to uncover the ports connecting with the low-pressure pipe, as this pressure is sufficient to raise this load. If the load is more than one-half the maximum, the low-pressure water alone will not lift it, unless it is only slightly in excess, and even then the velocity of the car will be too slow to be satisfactory. In such a case the operator moves the operating lever farther, so as to lift the main valve higher, and by so doing a portion of the ports of the high-pressure tank is uncovered, that is, the piston V^2 passes above the lower margin of the ports, and then water passes into the valve chamber from the high-pressure, as well as from the low-pressure pipe; as a result the pressure acting on the piston is higher than the pressure in the low-pressure pipe. If the load is only a trifle more than the low-pressure water alone can lift, only a small amount of water will be drawn from the high-pressure pipe, but if the load is nearly equal to the maximum, most of the water will be supplied by the high-pressure pipe, while when the load is fully up to the maximum, no water will be drawn from the low-pressure pipe.

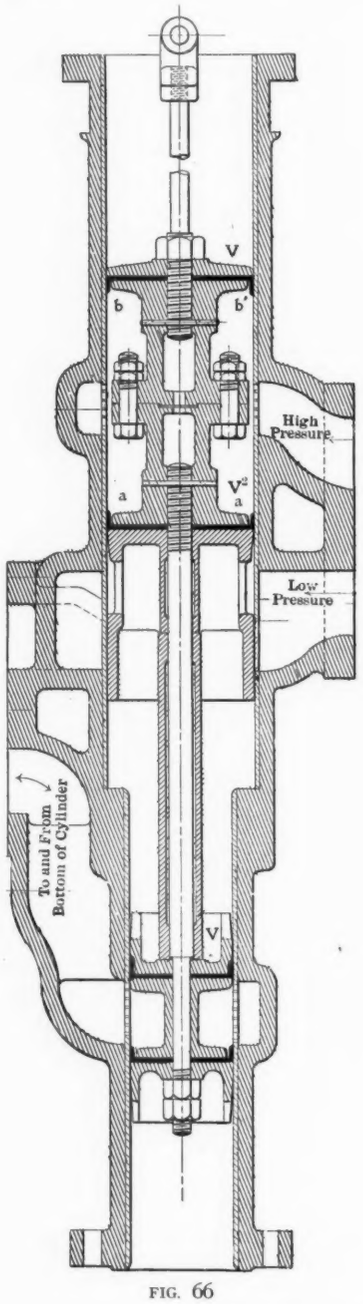


FIG. 66

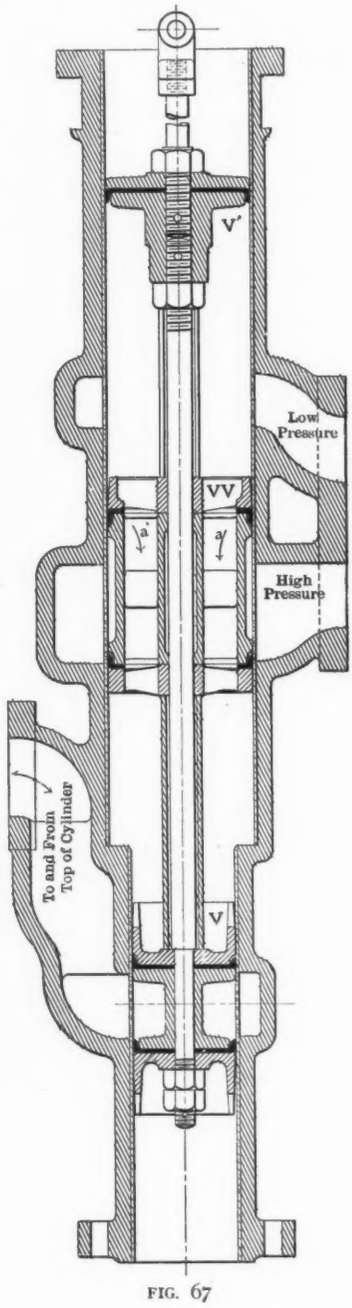


FIG. 67

From the foregoing explanation it can be seen that no matter how small the load may be, it will require just as much power to lift it as it would for the heaviest load that the low-pressure water can raise, but for any load between the latter and the maximum amount the elevator is designed to raise, the power will not be very far

from proportional to the load. The high-pressure water is generally double the low-pressure, the usual pressures being 200 and 100 pounds, respectively, so that the expenditure of energy is nearly in proportion to the work done for all loads greater than one-half the maximum.

When this system was devised, it was expected that in its operation the high-pressure water upon entering the valve chamber would not only flow into the cylinder, but would also back up into the low-pressure pipe, and to prevent this action a check-valve was placed in the low-pressure pipe, as shown in the drawing. The actual operation of these machines, however, has shown that the high-pressure water does not run back into the low-pressure pipe, unless the load is so great as to require a pressure nearly as great as that of the high-pressure water, so that for any load under, say, 75 per cent. of the maximum, the apparatus would operate perfectly if the check-valve in the low-pressure pipe were removed. It is not very easy to explain how water can run into the valve chamber from a pipe in which the pressure is 100 pounds, when water is running in from another pipe in which the pressure is 200 pounds, but it is nevertheless a fact that it does run in. If it did not run in the speed of the elevator car could not be kept up when the valve is raised just far enough to slightly open the high-pressure ports. To make this point clear, suppose the load is slightly in excess of what the low-pressure water alone can lift at full speed, then, if no high-pressure water is used, the car will rise at a slow velocity; if now the valve is raised so as to open the high-pressure ports, say, 5 per cent. of their full area, the speed will be at once reduced very decidedly, if the high-pressure water backs up into the low-pressure pipe and prevents water coming in from that source, because the opening of the high-pressure ports is so small that sufficient water to produce a high speed cannot pass through them. In actual practice, however, it matters little how slight the opening of the high-pressure ports may be, the effect is to give an increased speed; and if the car lever is moved very slowly over the portion of its movement that begins to open the high-pressure ports, the speed will be noticed to increase slowly and evenly as the lever advances. This could not be the result if the opening of the high-pressure ports had the effect of stopping off the flow from the low-pressure pipe, for if such were the action until the high-pressure ports were opened enough to permit water to pass through them in greater quantity than it previously entered through the low-pressure ports, the speed would be lower than with the low-pressure alone. Elevator engineers who are familiar with this problem have theorized upon it in an endeavor to find a plausible explanation of the action, and while no one appears willing to advance a decided opinion upon the subject, the general conclusion is that there is some kind of inspirator or injector effect produced, or probably both effects exist at once, the high-pressure water serving to suck the low-pressure water into the valve chamber as it rushes down past the low-pressure ports, and then, turning around just above piston V, it may rush into the ports leading to the circulating pipe, and draw in the low-pressure water with it.

In Fig. 65 it will be noticed that there

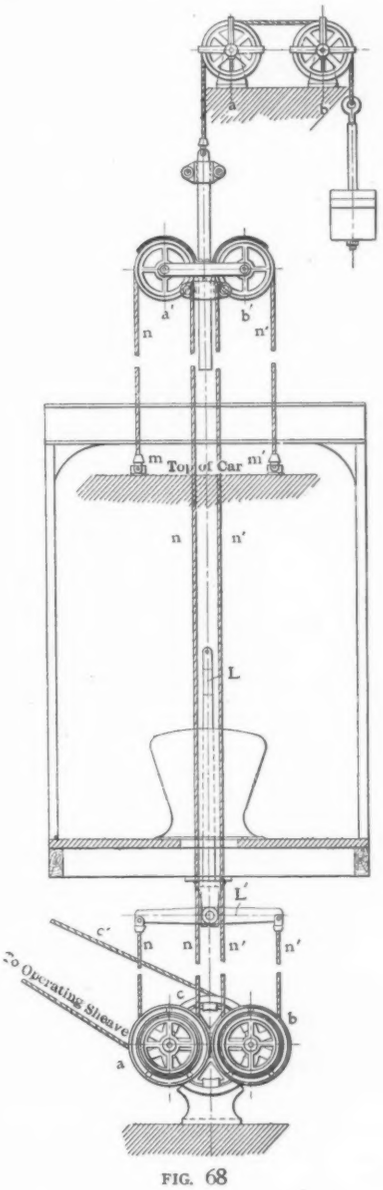


FIG. 68

is a relief valve at the top of the cylinder, while no such valve is provided with the low-pressure machines. This difference is made necessary by the presence of the check-valve in the low-pressure pipe. This valve is not required in low-pressure machines; therefore, if the car is stopped too rapidly on the down trip the water in the upper end of the cylinder can flow back through the throttle valve into the pipe. With the double-power system there is no escape for the water either through the low-pressure or the high-pressure pipes, hence a relief valve has to be provided at the top of the cylinder.

Non-circulating Valves

Double-power hydraulic elevators have been made by the Otis company with non-circulating as well as circulating valves. The former are used in cases where the varying weight of the lifting ropes is compensated for by the hight of a column of water rising in a stand-pipe connected with the bottom of the cylinder, the principle of which was fully explained in the article in the February issue.

Fig. 65 shows the circulating type. The valve and valve chamber of this type are shown in Fig. 66. It will be seen that on the right side the top port connects with the high-pressure, and the bottom one with the low-pressure pipe. On the left side there are two ports, one to connect with the lower end of the cylinder, and the other, which is just above it, to connect with the circulating pipe. The valve has the cup packings a and b turned toward each other, so as to hold the high-pressure water between them when the valve is in the central position, as drawn in Fig. 65.

The valve chamber and valve for the non-circulating machine are shown in Fig. 67, and as will be noticed differ considerably from the circulating type. In the valve chamber it will be noticed that the high-pressure port is below the low-pressure, and on the left side there is only one port which connects with the top of the cylinder. This is the same port, in so far as its position is concerned, as that in Fig. 66 which connects with the lower end of the cylinder. The port which in the latter figure connects with the circulating pipe, is closed up in Fig. 67. Looking at the valve in Fig. 67 it will be seen that the central valves $V\,V$ that shut off the flow of high-pressure water are different from the similar valves in Fig. 66. The latter are made so as to hold the high-pressure water between the two pistons, so that it cannot pass to the cylinder until the valves have been raised high enough to carry V^2 above the lower edge of the high-pressure port. In the non-circulating valve the action is the reverse of this. At all times the low-pressure water has free access to the entire valve chamber, through the central opening in the high-pressure valve $V\,V$, the arrows $a\,a$ indicating the path of the stream. In starting the elevator on the up trip the valve is depressed until the top of the lower valve V uncovers the lower port in the valve chamber, then water can flow into the upper end of the cylinder and the piston will be depressed. If it becomes necessary to use some of the high-pressure water, the valve is further depressed, until the upper end of valve $V\,V$ uncovers the upper part of the high-pressure port in the valve chamber, then high-pressure water will flow in and passing down through the valve $V\,V$ will

go into the cylinder together with the low-pressure water.

The non-circulating valve is not used very extensively, as it is required only in cases where the weight of the lifting ropes is compensated for by means of a standpipe. This arrangement is far more elegant than compensating chains dangling in the elevator well from the bottom of the car, but is considerably more expensive, and that in all probability fully accounts for its not being more generally adopted. In New York this arrangement is in use in the St. Paul Building and one or two others.

Otis Running-rope Method

The rope connections, shown in Fig. 65,

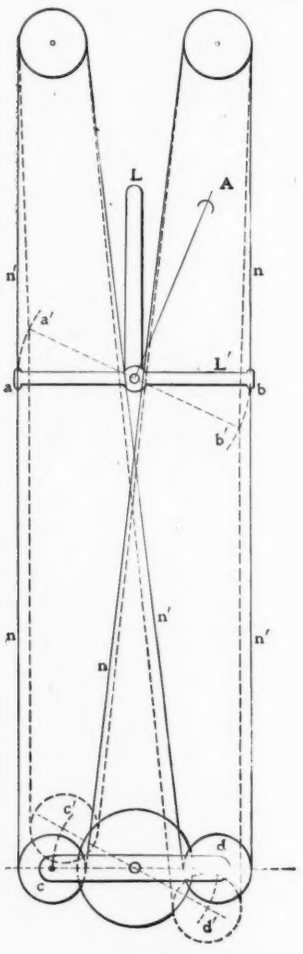


FIG. 69

for operating the pilot valve by means of the car lever L, represent one form of the running-rope system. The standard running-rope arrangement used by the Otis Elevator Company is shown in Fig. 68. The horizontal rock-lever L' is fastened to the same shaft as the lever L, and to its ends are secured the running ropes $n\,n'$. The upper ends of these ropes are made fast at the upper end of the elevator car, as shown at $m\,m'$. The n rope passes under a sheave a, attached to the side of sheave C, and then runs up the elevator well to the top of the building and passes over the sheave a', thence running down to the hitching point m on the car top. The n' rope passes under the sheave b attached to the side of sheave C, opposite to that on which the sheave a is mounted, and thence running up to the top of the building passes over the sheave b' and down to the top of the car to m'. If the lever L is moved in either direction it will lift one of the ropes and depress the other, and thereby cause the sheaves a and b to rotate and carry with them the sheave C. The movement of the latter sheave, through the rope C', turns the actuating sheave 1 on the pilot valve stand.

This rigging of the ropes is not quite the same as that known in Fig. 65, as the latter is arranged so that both ends of each running rope are attached to the ends of the rocking lever. Owing to this difference the ropes in passing up the elevator well have to cross over, so that the one that passes under the sheave on the right side at the bottom must pass over the left side sheave at the top. This way of arranging the ropes is clearly illustrated in the diagram Fig. 69, in which the solid lines show the position of the ropes when the car lever is in the central position, and the broken lines represent the position of the ropes, and lower sheaves, when L is shifted to the position A'. An examination of this diagram will show clearly why it is necessary to cross the ropes in the elevator well when all the ends are connected with the rocking lever L', and why they should not be crossed when the top ends are connected to the upper part of the car frame, as in Fig. 68. It will also be seen that in the arrangement of Fig. 69, if the operating lever is shifted to the position A, points a and b will be shifted to a' and b', and the lower sheaves c and d will be shifted to c' and d'; that is, these sheaves will be moved through distances equal to the movement of the ends of the rocking lever, or in other words through a distance equal to $a\,a'$. In the arrangement of Fig. 68, however, the movement of the lower sheaves is equal to one-half the distance through which the ends of the rocking lever are moved. In both cases it must be understood that the upper sheaves a' and b' are stationary.

A Puzzling Pilot Valve

The pilot valve shown in Fig. 65 has puzzled quite a number of engineers, for the reason that the valve chamber has an outlet which is generally plugged up, and the object of this outlet is not easy to trace. The construction of the valve, the position of the outlet, and its object can be made clear by the aid of Fig. 70, which shows on the left side a vertical sectional elevation of the valve chamber with the valve in the stop position, and on the right side another vertical section of the chamber taken at right angles to the first-named, while at the top a plan view is given showing the relative position of the three outlets of the chamber. The outlet that will almost invariably be found plugged up is at D. This opening was originally made for the purpose of connecting a pressure-regulating device intended to make the double-power system automatic in action, in so far as the use of high-pressure water is concerned. When this device is used, D is connected with the upper end of the valve chamber, and in the pipe connection there is a valve that is normally closed, but is controlled by a pressure regulator that in turn is connected with the upper end of the cylinder, and is, therefore, actuated by the pressure therein. The regulator is adjusted so as to act with a pressure considerably above the low-pressure water. The operation is as follows: If the pressure at the top of the cylinder, which is due to the load in the car, is more than can be maintained by the low-pressure water, flowing in at the required velocity, and is also great enough to actuate the pressure regulator, so as to open the valve in the pipe connection from D to the upper end of the valve chamber, then water will escape

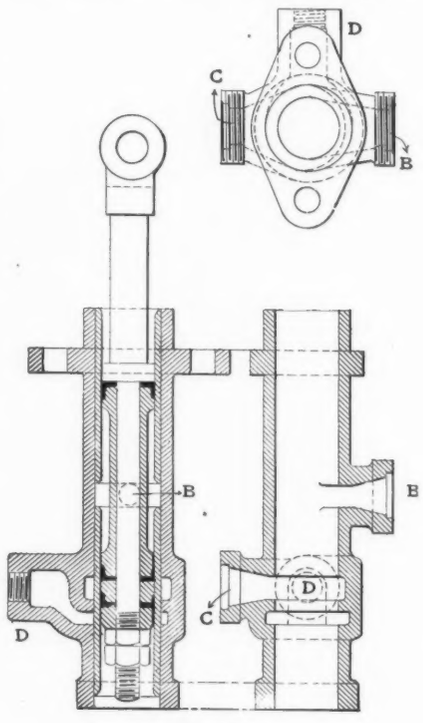


FIG. 70

from the upper side of the motor piston V', through this D connection, and thus permit the valve to rise higher and open the high-pressure valve wider, so as to let in more high-pressure water, and thus increase the car speed. In practice it has been found that this regulator is not as much of an improvement as might be expected, and if it gets out of adjustment slightly is liable to make the operation of the car far from satisfactory. If it is set to act at a pressure only slightly above the low-pressure water, it is liable to set the car in operation if an unusually heavy load is taken on. In the regular running

of the car, also, it is liable to produce an irregular motion, like an over-sensitive engine governor. For these reasons it has been practically discarded, and the opening *D* plugged up.

The Ideal Internal-combustion Engine

By E. N. Percy

Suppose, irrespective of patent rights, conservatism and other things that retard progress to make it more sure, an ideal internal-combustion engine could be constructed to combine the best points of each; what would it be like? As yet the gas-turbine problem is a long way from solution, and can reasonably be left out of consideration. Let us combine some of the features on paper, though practice alone can prove their worth.

The advantages and disadvantages of the two great classes of engines (four-stroke cycle and two-stroke cycle) are too well known to need much discussion. The four-stroke-cycle, while certain and economical, is heavier, more complicated and requires many more repairs. The two-stroke, while lighter and more powerful, is not so certain and economical, but the reasons for this are well known and can be eliminated, as I will try to show.

The two-stroke engine is without doubt the coming type, and is now the standard of many makers; most of the very large designs are of this class, with an auxiliary compressor (at least, in Europe). A single-acting high-speed has been proven the best running and most economical of steam engines [?—Eds.] because the pressure is all in one direction, keeping the parts together, and the different parts of the cylinder approximate the temperatures of the steam at their particular points of expansion. It is reasonable to suppose that the same would apply to the gas engine, and that one will use triple-cylinder, or even double-opposed engines, with their excellent balancing and consequent high-speed possibilities, rather than the ponderous types that seem to revert to the ancient types of steam engine. That the former types are actually being built successfully in large horse-powers at the present time is the writer's support of this argument.

Compounding the gas engine cannot greatly increase its economy, because it is impossible to run the high-pressure cylinder at a higher temperature than single cylinders run at now, and a cylinder receiving the gases at the usual exhaust temperature would develop very little power, as the expansion cools the gases proportionately. If the present stage were merely divided into two parts without using higher or lower pressures, nothing would be gained, as the high-pressure cylinder could not be maintained at the high half of the temperature cycle. As will be shown later, it is better that the heat be saved and used by other methods.

Two-stroke-cycle engines are not economical. In the first place, if it be compressed in the crank chamber part of the charge escapes around the bearings or through the joints; therefore, it should be compressed elsewhere. The charge also leaks around the piston rings from the inlet port to the exhaust port, and much of it mixes with the exhaust gases in forcing the latter out of the cylinder. All of this shows that in a two-stroke engine air only should be used to scavenge the cylinder and the fuel admitted after the exhaust port is closed, when there can be no waste. The most economical engines on the market use this method, some working on the four-stroke cycle, some on the two-stroke cycle, igniting by electricity, torch, hot chamber or by compression alone. Therefore the method is right.

Some objections also apply to the operation of a two-stroke-cycle engine. Backfiring in the crank chamber or other place of compression may be prevented by putting in the passage way a partition of metal gauze, which, on the well-known principle of the miner's lamp, cannot transmit flame. The distortion of the cylinders because of the cool gas coming in on one side and the hot exhaust leaving on the other can be eliminated by having the jacket arranged to cool the incoming side less, if at all. Otherwise the two-stroke is smoother, and more silent running than the four-stroke engine and possesses the important advantage of always having a downward, or crankward pressure which keeps the parts together and prevents knocking.

The starting of a two-stroke engine is the bugbear of most designers and engineers. The mixture may be spoiled by in or out leakage in the crank-chamber, by mixture with the exhaust gases, or by mixture with air from the exhaust port; or the suction may fail altogether when running slow, as by hand. All of these troubles are overcome when the engine is made of the fuel-injection type. It starts easily and without fuss, as the user of any reliable make of kerosene engine will testify; and, without adjustment, can use any fuel at hand that will burn and "inject." A large engine of this type will start nicely with compressed air, and the action can be continuous until ignition takes place, not interfering in any way with the cycle of the engine, but rather conforming to it.

Now in building up the hypothetical engine let us assume as the standard the triplex vertical for all large powers and high speeds, with separate compressors or blowers (hereafter described). Small merchandise engines, which no one should despise to manufacture, can be made with a single cylinder and crank compression, at competitive prices. Specially high-speed light or cheap engines for direct connection to dynamos, etc., can be made double-opposed.

Let the air to the inlet ports be supplied by a blower of the Sirocco type, delivering air at about five pounds pressure. This is a very uncomplicated addition to the engine. As gas is the acknowledged proper form for fuel, let it be delivered to the engine by another smaller blower, at a pressure above the compression of the engine. While such blowers are on the market, it is possible to build them on the same principle as a tiny steam turbine, or if this looks dubious to the uninitiated, let us have a simple compressor of one-seventh the capacity of the cylinder; it would cost less and run better than the valves and gear of a four-stroke-cycle engine. The engine should have fairly high compression; not so high that it must be built like a hydraulic press and impair the economy by excessive friction, but say 200 to 300 pounds. The fuel should be admitted by small valves, controlled by a governor, the ignition being at the start by a torch, after which it would be entirely automatic. The remaining features would be details to be worked out in the design.

Instead of wasting the heat in the jacket water, make use of the latent heat capacity of the water; instead of running through the jacket, it must boil there, taking up the heat as desired, and when sufficient pressure is generated the steam is injected into the cylinder with the fuel. Reintroducing this heat into the cylinder will improve the combustion and furnish power by the expansion of the steam. This feature has made a well-known make of engine one of the most economical in the market.

The engine outlined would embody the best points of engines long tried out in the open market. The moving parts would be all open and visible for attention, excepting in small sizes. The engine would utilize practically all of the jacket-water heat and could be made to utilize part of the heat in the exhaust gases. It would need very little water, less than an air-cooling device for circulating water. There would be no cumbersome auxiliaries, even a very large engine requiring only a small air compressor to provide for the next start. It could be perfectly governed, like a steam engine, and with any load exerts its impulses in regular succession, maintaining a torque wave varying in hight only, hence on light loads would tend to run even more smoothly. Such an engine could be built with modifications without infringing on patents, and would run much like a steam engine.

The writer is at the present time studying this subject and the application of turbine blowers in Germany, hence the confident reference to the possibilities of the hypothetical engine outlined.

The Gas Power Plant of the Norton Company

General Outline of Plant, with Report of Its Performance under Every-day Conditions. Average Coal Consumption 1.42 Pounds

Not long ago the Norton Company, of Worcester, Mass., installed a gas-power central-station extension to its steam plant, to facilitate the operation of its numerous motor drives of varying loads, employing therefor a 500-horse-power Westinghouse internal-combustion engine, direct-connected to a direct-current generator. The fuel for this unit is producer gas, generated from bituminous coal in a Loomis-Pettibone producer plant, the gas-holder of which has a capacity of 30,000 cubic feet.

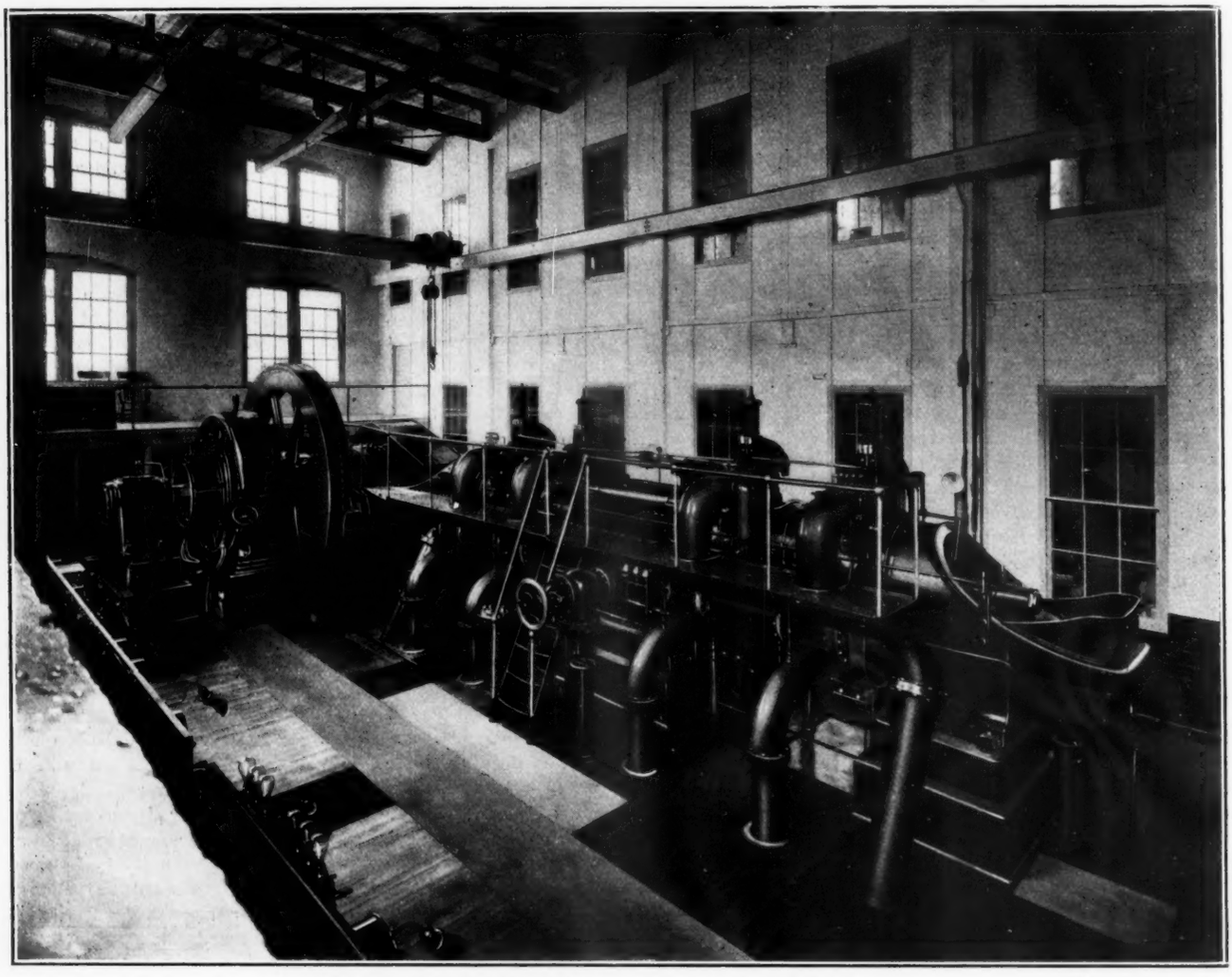


FIG. 1. GENERATING ROOM OF NORTON GAS POWER PLANT

Fig. 1 is a view of the generating room, Fig. 2 is a plan view showing the general arrangement of the plant, and Fig. 3 is an elevation. Both air and exhaust mains are carried to the outside of the building, the exhaust going straight up through the roof to avoid additional bends. The four exhausts from the engine discharge into a 20-inch cast-iron receiver main through long sweep bends. The gas and air reach the engine through double-duct piping running under the platform. See Fig. 4.

In a section of the basement (Fig. 5) is a circular gas tank, between the automatic regulator valve and the engine supply main, designed for two engines, for the purpose of introducing sufficient capacity back of the regulating valve to absorb the fluctuations due to the successive openings on the various inlet valves. This tank is not an absolute necessity, but has proved useful where the gas supply is measured by meter. To provide means for cleaning the gas mains between the engine and the producer, the Y-section shown in the engine-room basement has been provided.

Although only one unit is installed, a second is contemplated. The plant will then occupy a building 60x64 feet, or 6.4 square feet per kilowatt (the engine occupies 2.08 square feet per kilowatt), including ample passageways and all auxiliary machinery.

The engine is of the horizontal double-acting tandem type operating on the four-stroke cycle. Having two double-acting cylinders in tandem, it gives a power impulse on each forward and backward stroke, as in a single-cylinder double-acting steam engine. The revolving part of the generator is mounted solidly upon the extended engine shaft with an adjustable outboard bearing. The pistons "float free," supported by front, center and rear crossheads; the cylinder body, being of symmetrical design, is unrestrained in the adjustment to its internal fiber stresses. The engine is anchored to

the foundation at the forward housing, but is free to expand and contract longitudinally on center and rear sole plates.

Each piston is a symmetrical one-piece casting, without internal ribs, mounted permanently on the piston-rod. It is packed by sectional cast-iron rings with keepers. For convenience in handling, the piston-rod is made in two parts united at the center crosshead in a split socket, each half supporting a piston. To obtain access to either cylinder it is, therefore, unnecessary to remove more than one cylinder-head. The forward piston is then removed through the main housing, the other through the rear. These heads are packed by sectional metallic packing lubricated internally.

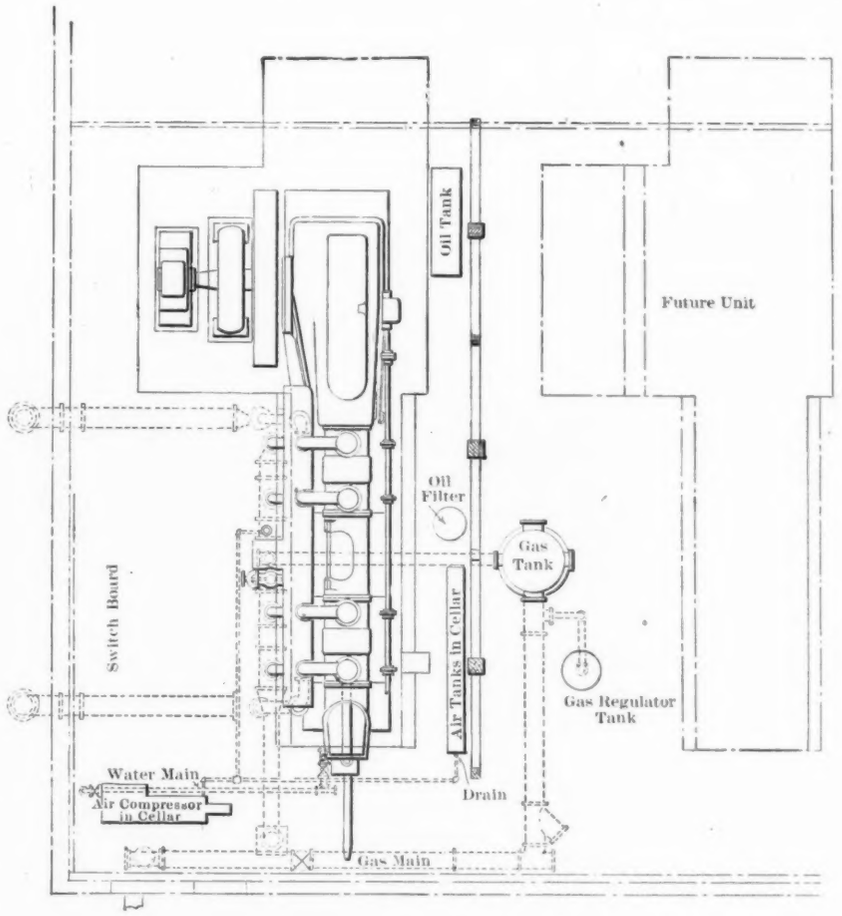


FIG. 2. PLAN VIEW OF NORTON PLANT

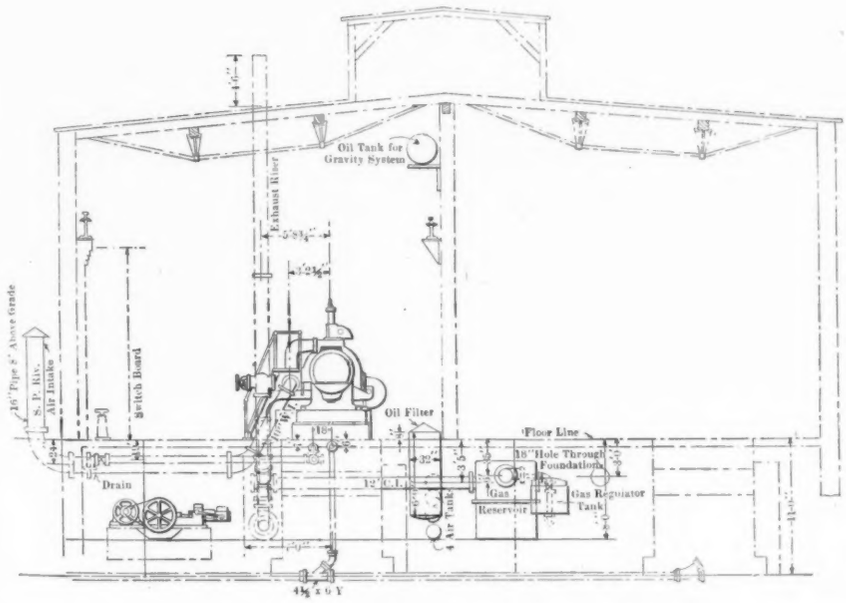


FIG. 3. SECTIONAL ELEVATION OF NORTON PLANT

The admission and exhaust valves are located, respectively, above and below the axis at the two ends of the cylinder. They are directly in line and have large openings into the cylinder body, which makes it an easy matter to inspect the interior of the engine without removing the cylinder-heads. In order to give free access to the exhaust-valve mechanism from the main floor the entire engine is raised about two feet above the floor level on concrete piers.

All parts of the engine subjected to the heat of combustion are water-cooled. The piston-rod water enters at the center crosshead, flows in both directions through the bore of the rods, thence through the two pistons, and finally discharges at the front and rear crossheads. The exhaust valve and the exhaust-valve bonnets are water-cooled, but not the inlet valves. Each of these water circuits has a separate outlet, so that the temperature of each working part may be individually judged; open funnels enable the attendant to feel of the water at times and see whether it is running uniformly. The various circuits are arranged on the series counter-current principle, so that in contiguous parts the higher temperature of the exit water will tend to balance the lower temperature of the inlet water.

Cylinder and piston-packing lubrication is accomplished by means of positive, sight-feed oil pumps driven by the engine. Cylinder-oil is not introduced in a continuous stream, but by timed injection. This occurs during the admission stroke only, just as the piston passes the oil port. At present three gallons of cylinder-oil are required per week. Engine oil is handled by a continuous gravity system supplied by a pump also driven by the engine. This oil is thoroughly filtered each time it circulates around the system so that the foreign matter accumulating in the crank-pits may be removed.

Both the admission and the exhaust valves are of the simple poppet type, seating in the direction of internal pressure, assisted by spiral springs. They are operated by eccentrics on a lay shaft driven by the main shaft through a set of spur gears. Instead of using one eccentric for each valve, one eccentric drives both the admission and exhaust valves of one end of a cylinder through a suitable combination of curved levers.

Two independent ignition systems are used; the igniters are located on opposite sides of the cylinder. One, the familiar "make and break" system, is operated by a small lay shaft paralleling the cylinders and driven by the main shaft through an adjustable drive by means of which the point of ignition can be advanced or retarded at will when the engine is running. The other is a magnetic system which requires no lay shaft, but which operates from a revolving electrical con-

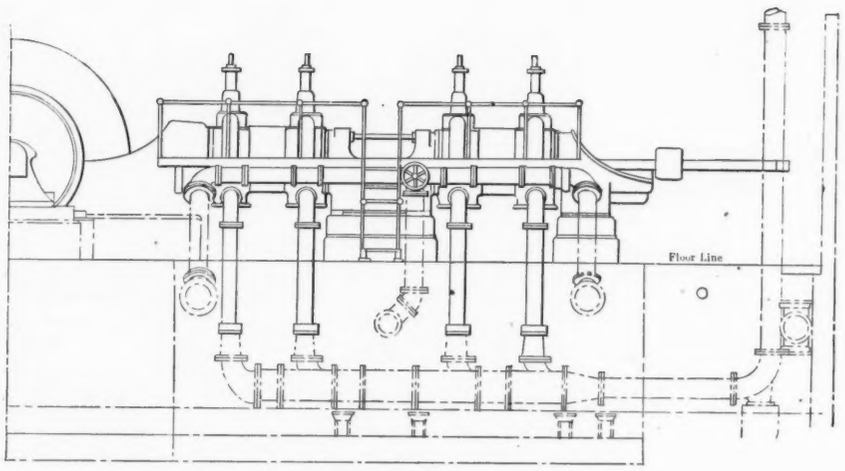


FIG. 4. SHOWING PIPING UNDER ENGINE PLATFORM

tactor geared to the main lay shaft. The impulses of current delivered by this contactor to the several igniters operate them through the medium of electromagnets connected in series, so that the energizing of all the magnets takes place and ceases exactly at the same instants. The point of ignition can be changed at will, by slightly revolving the casing of the contactor.

In this engine the seat of governor control is at the inlet valve, where the proportioning of gas and air and the mixing thereof are also carried out. This enhances regulation and avoids the disturbing effect of unused mixture that may have passed the mixing valve but become pocketed, for the moment, between the valve and cylinder.

An oil-relay system is interposed between the governor and mixing valves to relieve the former of all work of valve movement. This is accomplished by an oil-pressure cylinder under control of the governor, the combination resulting in very close regulation. In addition to the main governor a speed-limit device is located at the periphery of the fly-wheel. This consists of an iron bolt mounted radially in the fly-wheel rim and held by a spring of adjustable tension, and it is anticipated, should the engine speed exceed the safe limit, that this bolt will be carried out by centrifugal force and trip a switch, which will instantly open the igniter circuits of the several cylinders and thus "kill" the ignition.

An automatic compressed-air system is employed to start the engine. After the first few revolutions of the engine one of the four regular combustion cycles ensues, and the instant that ignition occurs the compressed air is automatically shut off by a check-valve. The air supply continues, however, until both cylinders have "caught" their ignition.

The accompanying table and the curves in Fig. 6 summarize the operating results of the Norton gas power plant during the first seven weeks of commercial service. It will be noted that the average daily run is 10 hours, with a half day on Saturday. This leaves a daily standby period of 14 hours, with 36 hours' shut-down over Sunday. This time is made use of, however, for cleaning the producer. The coal charges to the "producer" include what may be termed normal operation, i.e., exclusive of fuel required for building new fires. The latter is taken into account under the head of "total" coal, which amounts to about 10 per cent.

Referring to the curves, Fig. 6, the fuel characteristic of a gas-power plant conforms closely to a straight line, as shown by the "total coal" line, which is averaged from a large number of daily runs. From this line the fuel rate curves are derived.

As regards the attendance required to operate the gas equipment, one man takes care of the gas-engine unit and another

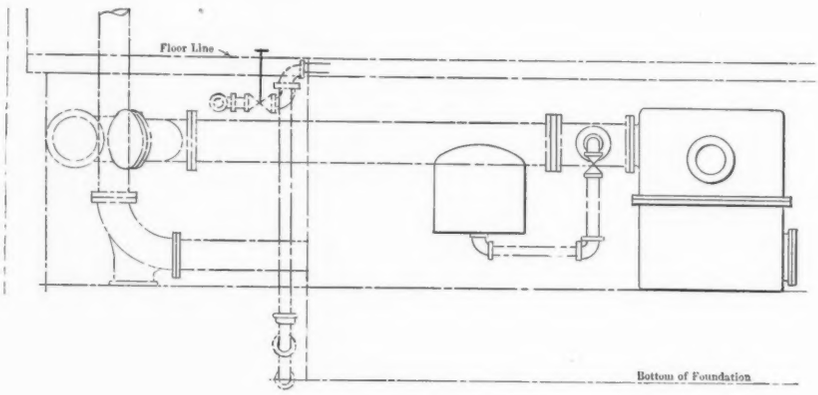


FIG. 5. GAS TANK IN BASEMENT

the producer, both under the direction of the chief engineer, who also has under his charge the old steam plant. Extra help for cleaning the producers is, of course, required.

SUMMARY OF OPERATING DATA OF GAS POWER PLANT OF THE NORTON COMPANY, WORCESTER, MASS.

Week Ending.	Hours Run.	Output Kw.-hr.	‡ Coal Burned, Lb.			Coal per Kw.-hr.		Generator Eff'cy.	Coal per B. H. P.-hr.		Heat Consumpt'n.*		Plant Efficiency.*		Station Loading Factor.	Average Load, Per Cent. Engine Rating.
			Producer.	New Fires.	Total.	Producer.	Total.		Producer.	Total.	B.t.u. per Kw.-hr.	B.t.u. per B. H. P.-hr.	Elec.	Brake.		
Jan. 6...	45- 5	10,150	20,690	1,400	22,090	2.03	2.17	92	1.39	1.49	28,400	19,500	12.00	13.1	20.2	75.0
Jan. 13...	50- 5	11,900	24,600	2,700	27 300	2.07	2.29	92	1.42	1.57	29,000	19,900	11.75	12.9	23.6	79.0
Jan. 20...	55	13,200	24,530	2,570	27,100	1.86	2.05	92	1.28	1.41	26,000	17,900	13.10	14.2	26.2	80.0
Jan. 27...	54-40	12,400	22,500	2,000	24,500	1.84	2.00	92	1.26	1.37	25,800	17,600	13.20	14.5	24.3	74.8
Feb. 3...	55	13,600	23,800	2,400	26,200	1.75	1.93	92	1.20	1.32	24,500	16 800	13.90	15.2	27.0	82.4
Feb. 10 ..	55	13,000	24,265	3,060	27,325	1.87	2.10	92	1.28	1.44	26,200	17,900	13,00	14.2	25.8	78.8
Feb. 17...	55	13,000	23,700	†2,500	26,200	1.82	2.01	92	1.25	1.38	25,500	17,500	13.40	14.5	25.8	78.8
Total..	369-50	87 250	164,085	16,630	180,715											
Average..	53	12,464	23,441	2,376	25,816	1.88	2.07	92	1.29	1.42	26,300	18,050	12.96	14.1	21.9	78.7

*For continuous running not including 10 per cent. loss in pulling fire weekly.
†Estimated from previous runs.
‡Med. grade Penn. bituminous coal up to Jan. 21. Pocahontas slack thereafter. Assumed 14,000 B.t.u. average.

Reactions between Compound-wound Generators Operating in Parallel

By Clarence A. Boddie

The parallel operation of compound-wound generators is treated in almost every text-book on direct-current machinery and is so often discussed in engineering literature that it would seem as if there were little left to be said about it. Almost every electrician or engineer knows how to connect up and successfully operate such machines. All are familiar with the equalizer connection and know that it is upon this feature that the stability of parallel working depends. Yet it is not clear to all just how and why the machines are mutually adjusting.

Consider the usual problem of two similar compound-wound generators operating in parallel but driven by independent engines. Fig. 1 is a diagrammatic representation of two such machines, where 1 indicates the armature of machine No. 1; C_1 represents the series-field winding, S_1 the shunt-field winding, R_1 the shunt resistance. The same characters with the subscript 2 indicate corresponding parts of machine No. 2; K is the equalizer switch, $T\,T'$ are the bus-bars. The arrows show the proper direction of the current under normal conditions. Suppose the equalizer switch K to be open and that No. 1 engine slows down slightly. Its voltage will then be less than that of No. 2, and if the fall in speed is not too great the only effect will be a decrease of current. This decrease of current decreases the series-field excitation, and if the machines are over-compounded the current will continue to decrease until it is reversed through the armature and series-field winding. This reverse current may overpower the shunt-field winding and thus reverse the polarity of the generator. If the machines are under-compounded, this will not occur, unless the change in speed is abnormally large. Large railway power stations are often operated in parallel with each other without an equalizer connection between them, but in such cases much trouble is experienced from reversals unless the series windings are shunted so as to make the machines under-compound.

Now suppose that the equalizer switch is closed and that machine No. 1 drops in speed. The potential established by it at A is less than at first, and therefore less than that established at B by No. 2; but A and B are connected by the equalizer and must be at practically the same potential. If the voltage of No. 1 does not rise to that of No. 2, it follows that current must flow from No. 2 through the equalizer to A, and thence through the series winding C_1 in the proper direction, and through the armature 1 in the reverse direction. The field is always excited in the proper direction, although the armature current may be reversed, thereby driving the armature in the original direction as a motor. One function of the equalizer, then, is to prevent reversal of the field magnetism.

In practice, when one machine slows up slightly it is observed that the lagging machine does not take its share of the load. The voltage on the bus-bars drops slightly, but the armature current is not reversed unless the fall of speed is excessive. The popular explanation of this is that current through the equalizer builds up or increases the field of the lagging generator, thereby bringing up its voltage. But why the load is differently distributed when the speed of one generator drops or its field resistance is changed is a phenomenon which, so far as I know, has never been satisfactorily explained.

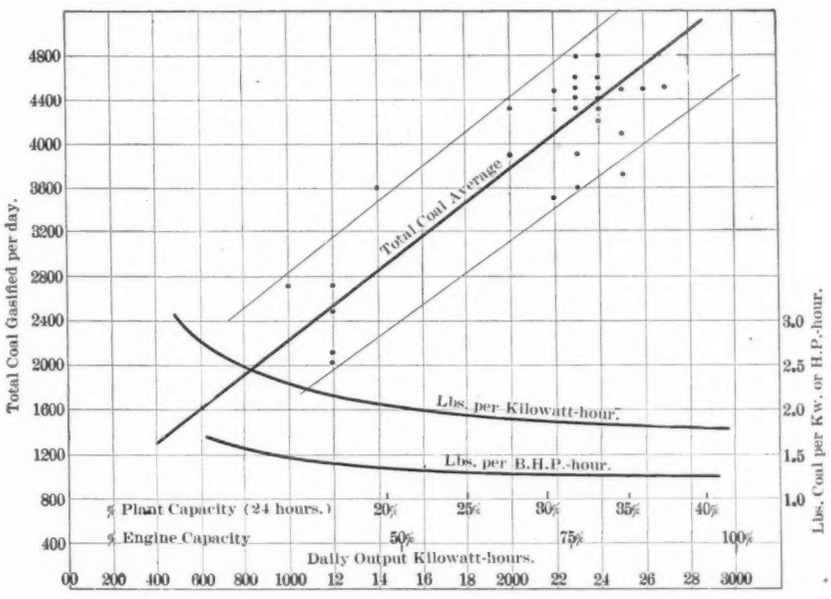


FIG. 6. OPERATING EFFICIENCY CURVES OF NORTON GAS POWER PLANT

As the result of considerable thought in this line I have come to the conclusion that the two most important factors are armature reaction and armature "resistance drop." By far the most potent of these factors is armature reaction, for

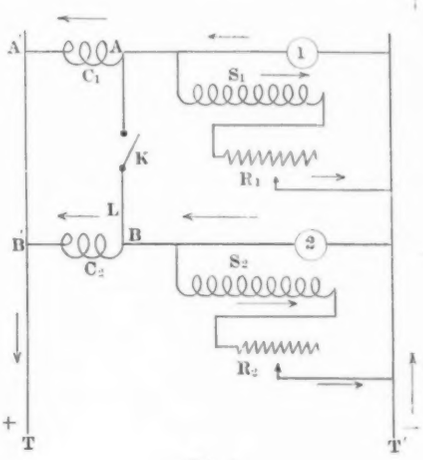


FIG. 1

without it parallel operation of dynamos would be impracticable if not impossible. The popular explanation is entirely inadequate to account for observed results, as will be seen from the following:

The equalizer connection puts the series-field windings in parallel with each other and, as will be more clearly seen from Fig. 2, the current through them simply obeys the law of the divided circuit. If the equalizer be gradually shortened, the junctions A and B, Fig. 1, will finally merge into the common junction $A\,B$, Fig. 2; similarly, A' and B', Fig. 1, become $A'\,B'$, Fig. 2. This change will not disturb the distribution of currents passing through the respective coils. It is plain that all the current delivered by both armatures in Fig. 2 must pass through the junction $A\,B$. The current must divide at this point, part going through each series coil, and the part in each must be inversely proportional to the resistance of the coil. Hence, the relation between the currents in the two coils depends only on their relative resistance, and is entirely independent of the relative strengths of current in the armatures; also, if the load on the bus-bars be constant the current through the respective series coils will be constant. From this it is evident that any change in speed, provided the total cur-

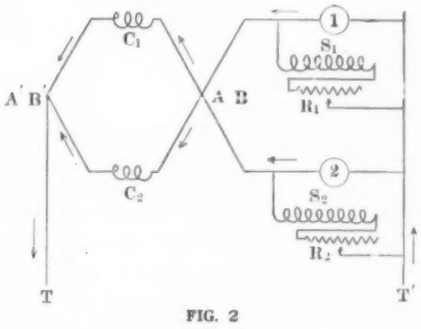


FIG. 2

rent output is unchanged, will not affect the field excitation of either generator. Therefore, the current in the equalizer does not build up the field of the lagging machine, but merely maintains it at its original strength; that is, it supplies the series winding of the lagging machine with the exact amount of current by which its armature is deficient, in comparison with the other armature. Suppose the total current drawn from the bus-bars is 1000 amperes, each machine normally supplying 500 amperes, and the resistances of the field coils being equal. If one machine should for some reason deliver only 400 amperes, the other must deliver 600, the total current delivered at the equalizer remaining 1000; of the 600 delivered by the one, only 500 goes through its own series coils, the other 100 going through the equalizer and combining with the 400 of the lagging machine completes the 500 amperes "belonging to" its series coil.

From this it is obvious that for a constant-load current on the bus-bars the equalizer keeps the series fields constant, and if the voltage across the bus-bars is kept constant the shunt-field currents will be constant and therefore the combined field excitation will be constant, thus placing the compound-wound machines on the same footing as shunt machines. But strange to say, shunt-wound machines in parallel are generally supposed to need no explanation. In books on the subject it suffices to state that shunt machines operate successfully in parallel.

The nature of armature reaction has been fully dealt with elsewhere, but it may be profitable to consider it here, since so much depends on it. The conditions are most clearly set forth in the bi-polar diagram, such as Fig. 3, in which the end sections of the wires on the armature are indicated by the small circles. The current in those marked with a cross is supposed to be flowing from the reader, and in those marked with a dot is is considered as flowing toward the reader. This will be the case when the magnet poles are as shown and the armature revolves in a clockwise direction. In a generator the brushes are shifted ahead, as indicated, to obtain sparkless commutation. The line *A—B* drawn between the brushes separates the conductors into two groups. Each conductor marked with a dot may be considered as joined to the corresponding conductor with a cross on the opposite side of the line *A—B*, thus making one turn or loop of wire. These separate turns form a magnetizing coil with its axis at *A—B*, which produces a north pole at *A*. The magnetizing force of this coil may be represented by the vector $o\,c$ which may be resolved into two components, $o\,a$ and $o\,b$. The component $o\,a$ is the back magnetizing force of the armature, since it is opposed to the field-magnetizing force. The component $o\,b$ is the cross-magnetizing force. The component $o\,a$ is produced by the ampere turns included in the angle $2\,\Phi$, where Φ is the angle of lead. The component $o\,b$ is that produced by the remaining ampere-turns.

From this it follows that the armature exerts a demagnetizing action on the field and that this action increases with the brush lead and with the armature current. If the field excitation be kept constant, as in compound generators in parallel, any increase in armature current will decrease the field m.m.f., and hence decrease the magnetic flux through the armature core, which in turn decreases the voltage developed, other things being constant. Also, an increase of current will increase the drop of voltage in the armature due to resistance. Hence, there are two causes which reduce the terminal voltage of a generator as the current increases, the field and speed being constant.

Again consider what happens when the generators are connected as in Fig. 1, supposing No. 1 to slow down. Its field is constant and hence its voltage is reduced and being less than that of No. 2, current from No. 2 instantly starts to rush backward through No. 1 armature. But

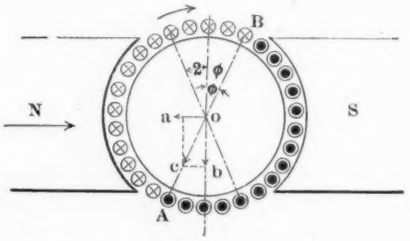


FIG. 3

in order to reverse, the current must first decrease to zero. As the current in No. 1 armature is decreasing, its armature reaction and resistance drop are decreasing and therefore its voltage is gradually increasing. The opposite of this is true of No. 2, for its current is increasing, and hence its reaction and resistance drop are increasing while its voltage gradually decreases.

The voltage of No. 1 is increasing while No. 2 is decreasing, therefore their difference of voltage is decreasing. The rate of change of current which depends on this difference of voltage must also decrease, and when the two voltages become equal the change of current in their armatures ceases; hence, the machines are in equilibrium. But the current of No. 1 is less and that through No. 2 is greater than the original values. This accounts for the behavior observed in practice.

If the field resistance be increased in No. 1 the effect is the same as a decrease in speed. Since the m.m.f. of the field is not sufficient to overcome the back m.m.f. of the armature and maintain the original flux, the flux decreases, thereby decreasing the terminal voltage, which decrease produces a difference of voltage between the two machines as before, thus causing the current of No. 1 to decrease and that of No. 2 to increase until equilibrium is attained.

These principles hold for any machine, series-, shunt- or compound-wound. It may be noted that the explanation for the shunt-wound machine is identical with that for the compound- or series-wound machine when the equalizer is used.

Machines of different sizes and types may be operated in parallel when the equalizer is used, but in case the machines are of different types the distribution of load may not be the same for all loads, since the machines have different proportions of armature reaction, etc. When machines of the same type but of different sizes are operated together, the currents through the series coils should be proportional to the respective capacities of the machines, and hence their resistances should be inversely proportional to their capacities.

The degree of compounding of several generators as a whole may be changed by shunting the series coils of one machine, for in doing so all are shunted since they are all connected between the equalizer and the positive bus-bars. The degree of compounding of a generator working alone may be changed by means of the shunt, but if this generator is worked with others its relative compounding will not be changed.

Inserting a small resistance in series with the series-field winding will decrease the compounding of a particular generator, since the proportion of current through it is lessened. But since the total output remains the same, more current must pass through the series coils of all others on the same circuit; hence their compounding is increased.

The stability of generators in parallel is increased by increasing the brush lead because this increases the armature reaction and, consequently, a given change of current will make a greater change in terminal voltage; under this condition a given change of speed or field resistance will produce a less change of distribution between machines than with less brush lead.

It is hoped that these principles will enable those handling such machines to understand more clearly the nature of their action and to account for many puzzling phenomena in connection with them.

[It has long been known that constant-potential dynamos having considerable armature reaction work much better in parallel than those having low reaction. The now obsolete Eickemeyer generator, which had relatively small distorting and no directly demagnetizing armature ampere-turns, combined with very low armature resistance, was so sensitive when operated in parallel that such operation was dangerous to the machines. It is not

strictly accurate, however, to say that without armature reaction parallel operation would be impracticable. Of course, there is always some demagnetizing armature reaction in the ordinary type of machine, but if the resistance of the armature circuit and brush connections be moderately high, and the regulation of the prime mover be good, parallel operation would be entirely practicable with no demagnetizing reaction at all.

For example, suppose the two machines and the circuits to have the following data:

	Armature No. 1	Armature No. 2	Remainder of Circuit
Speed	600	600	...
Total e.m.f.	600	600	...
Current	500	500	1000
Resistance .	0.04	0.04	0.58
Drop, volts..	20	20	580
Brush e.m.f.	580	580	...

Now suppose that the speed of No. 2 dynamo should drop to 561.3 revolutions per minute, and that the field and speed of No. 1 could be kept absolutely unchanged; then the conditions would be as follows:

	Armature No. 1	Armature No. 2	Remainder of Circuit
Speed	600	561.3	...
E.m.f.	600	561.3	...
Current	967.74	0.	967.74
Resistance ..	0.04	0.04	0.58
Drop	38.7	0.	561.3
Brush e.m.f..	561.3	561.3	...

In other words, the speed of No. 2 would have to decrease 6½ per cent., in order to allow No. 1 to send current through it backward. As a matter of fact, however, the field strength of No. 1 machine would not remain constant, on account of the abnormal armature drop, so that the speed of No. 2 could decrease appreciably more than 7 per cent. before it ceased taking any of the load.—EDITORS.]

Gasolene Not So Dangerous

At the recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, E. W. Roberts performed some startling experiments with gasolene, lighting the vapor as it arose from an ordinary can and pouring gasolene into it as it burned, showing that it could not flash back into the can as that was full of gasolene vapor forming rapidly enough to expel the air and burning only after it issued into the atmosphere. The only danger of explosion is when a very small quantity of gasolene evaporates in a vessel, forming not enough vapor to expel the air but sufficient to make with it an explosive mixture.

September 23 has been set apart as "Robert Fulton Day" at the Jamestown Exposition, when will be celebrated the centennial anniversary of the first voyage up the Hudson of Fulton's steamboat "Clermont." The actual date when the trip was begun was August 1, 1807.

Most Efficient Ratio of Steam Cylinders in Direct-acting Compound Pumps

BY F. F. NICKEL

Ordinarily there is no cut-off on either of the cylinders in a compound direct-acting pump. The load is constant throughout the stroke, and in the absence of a fly-wheel the piston will stop the moment the steam is cut off.

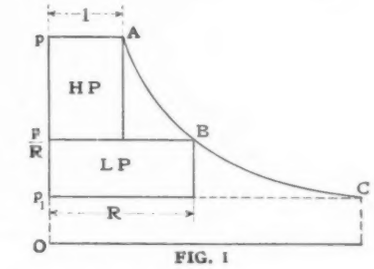


FIG. 1

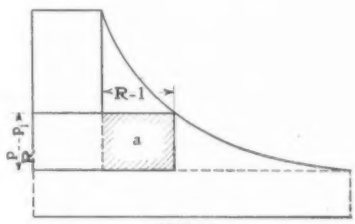


FIG. 2

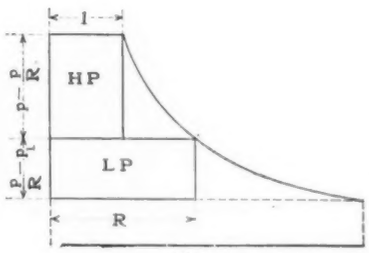


FIG. 3

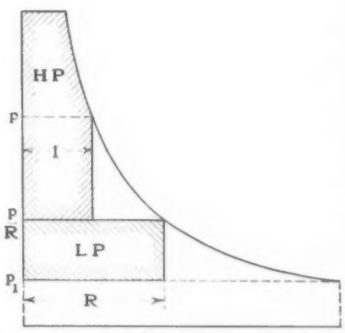


FIG. 4

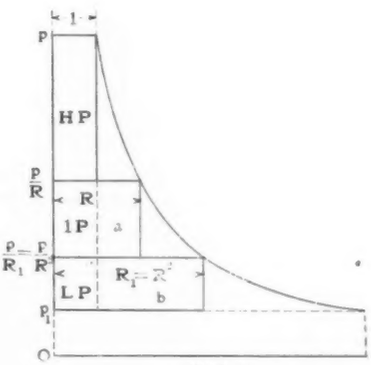


FIG. 5

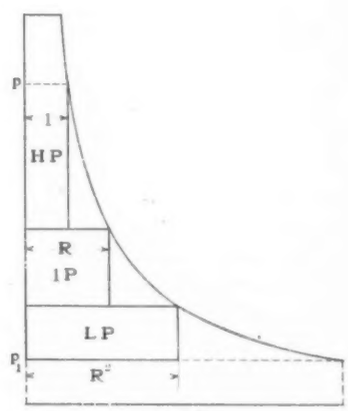


FIG. 6

If we assume the high-pressure back-pressure line to be a straight line of even pressure, the indicator diagrams will be represented by rectangles. In practice this back-pressure line, which is also the low-pressure steam line, will slope down gradually from a higher point and give a slightly increased power. On the other hand, the losses between the cylinders will diminish the power slightly, so if we neglect both no serious error will be introduced. In the diagrams given herewith p and p_1 are absolute pressures.

In Fig. 1 *A—B—C* represents the theoretical steam expansion line, in which the high- and low-pressure diagrams are drawn to a scale of volumes. The high-pressure cylinder volume can be taken as unit, and the ratio between the two cylinders being R, the low-pressure cylinder volume is represented by a line whose length is equal to R. The problem is now to find the value of R, for which the area inclosed by the high-pressure and low-pressure diagrams is a maximum. This is evidently the case when the rectangle a, Fig. 2, is a maximum. This rectangle a represents the gain in a compound pump over a simple pump, and a little consideration makes it clear that by changing the diameter of the low-pressure cylinder in either direction, a is decreased until the following limits are reached:

$LP = HP$; $R = 1$; $a = o$.

$LP = HP \times \frac{p}{p_1}$; $R = \frac{p}{p_1}$; $a = o$.

Between these two extremes there must be a maximum, and the object of the following calculation is to find the value of R, for which this result is obtained. Comparing Figs. 2 and 3, we find that:

$$a = (R-1)\left(\frac{p}{R} - p_1\right);$$

$$a = p - p_1 R - \frac{p}{R} + p_1;$$

$$a = p + p_1 - \left(p_1 R + \frac{p}{R}\right).$$

This expression is a maximum when $x = p_1 R + \frac{p}{R}$ is a minimum, and this is the case when the differential coefficient of x regarded as a function of $R = o$.

$$\frac{dx}{dR} = p_1 - \frac{p}{R^2} = o,$$

$$p_1 = \frac{p}{R^2}.$$

FORMULA:

$$R = \sqrt{\frac{p}{p_1}}. \qquad (1)$$

The areas of the two diagrams, Fig. 3, are:

$$HP = \left(p - \frac{p}{R}\right) \times 1 = p - \frac{p}{\sqrt{\frac{p}{p_1}}}$$

$$= p - \sqrt{p p_1}$$

$$LP = \left(\frac{p}{R} - p_1\right) \times R = p - p\sqrt{\frac{p_1}{p}}$$

$$= p - \sqrt{p p_1}.$$

This means that the best results are obtained when the work is distributed equally between the two cylinders. It has been found in practice that no advantage is gained by a ratio of cylinders greater than 1:4, and this should be taken as the upper limit.

p_1 is the back pressure in the low-pressure cylinder and should be 16 pounds for non-condensing engines, and 6 pounds for condensing engines.

EXAMPLE: Boiler pressure = 100 pounds; initial pressure (absolute) in the high-pressure cylinder = 100 + 10 = 110 pounds.

Ratio: $R = \sqrt{\frac{110}{16}} = 2.63$ for non-condensing engines.

Ratio: $R = \sqrt{\frac{110}{6}} = 3.9$ for condensing engines.

In a similar manner we may find the most economical ratio between the cylinders of a triple-expansion pump, the diagrams of which are represented by Fig. 5, in which HP is the diagram of the high-pressure cylinder, IP that of the intermediate cylinder, and LP that of the low-pressure cylinder. There are two ratios:

$$R = \frac{IP}{HP}, \text{ and } R_1 = \frac{LP}{HP},$$

and it will be necessary first to find a relation between the two.

Considering the expansion in the intermediate cylinder alone, the back-pressure in formula (1) is:

$$p_1 = \frac{p}{R_1},$$

therefore a is a maximum for

$$R = \sqrt{\frac{p}{\frac{p}{R_1}}} = \sqrt{R_1}.$$

FORMULA:

$$R^2 = R_1. \qquad (2)$$

This means that the ratio between the intermediate and high-pressure cylinders is equal to the ratio between the low-pressure and intermediate cylinders.

The work represented by the three diagrams, HP, IP, and LP, is a maximum when $a + b =$ maximum.

From Fig. 5 we find that:

$$a = (R-1)\left(\frac{p}{R} - \frac{p}{R^2}\right) = p - \frac{p}{R} - \frac{p}{R} + \frac{p}{R^2};$$

$$b = (R^2-1)\left(\frac{p}{R^2} - p_1\right) = p - p_1 R^2 - \frac{p}{R^2} + p_1.$$

$$a + b = 2p - \frac{2p}{R} - p_1 R^2 + p_1;$$

$$a + b = 2p + p_1 - \left(\frac{2p}{R} + p_1 R^2\right).$$

$a + b =$ maximum when

$$x = \frac{2p}{R} + p_1 R^2 = \text{minimum}.$$

This is the case when the differential coefficient $= o$.

$$\frac{dx}{dR} = -\frac{2p}{R^3} + 2p_1 R = o;$$

$$2 p_1 R = \frac{2p}{R^2};$$

$$R^3 = \frac{p}{p_1}.$$

FORMULA:

$$\frac{IP}{HP} = R = \sqrt[3]{\frac{p}{p_1}}. \qquad (3)$$

FORMULA:

$$\frac{LP}{HP} = R^2 = \sqrt[3]{\left(\frac{p}{p_1}\right)^2} \qquad (4)$$

The areas of the three diagrams, Fig. 5, are:

$$HP = \left(p - \frac{p}{R}\right) \times 1 = p - \sqrt[3]{p p_1};$$

$$IP = \left(\frac{p}{R} - \frac{p}{R^2}\right) \times R = p - \sqrt[3]{p p_1};$$

$$LP = \left(\frac{p}{R^2} - p_1\right) \times R^2 = p - \sqrt[3]{p p_1};$$

which shows that here also the load is distributed equally between the cylinders.

In triple-expansion condensing engines the back pressure should be taken to = 5 pounds.

EXAMPLE: Boiler pressure, 100 pounds; initial pressure (absolute), 110 pounds. (This allows 4.7 pounds for wire-drawing.)

Ratio:

$$\frac{IP}{HP} = R = \sqrt[3]{\frac{110}{16}} = 1.9;$$

$$\frac{LP}{HP} = R^2 = 3.6$$

for non-condensing engines.

Ratio:

$$\frac{IP}{HP} = R = \sqrt[3]{\frac{110}{5}} = 2.8;$$

$$\frac{LP}{HP} = R^2 = 7.8$$

for condensing engines.

In low-service compound pumps, and also in triple-expansion pumps, where the weight of the reciprocating parts is heavy it is often desirable to use a cut-off in order to stop the momentum of the pistons.

The formulas given are equally well applicable to these types of engines if we insert the terminal pressure in the high-pressure cylinder instead of the initial. These cases are represented by Figs. 4 and 6, and it will be noticed that although the maximum effect is obtained as before, the load is no longer distributed equally between the cylinders, the high-pressure cylinder getting an extra share of the work.

In conclusion, the formulas given should be used with discretion. A greater ratio of cylinders than that given by the formula should never be used, as that would mean less power at increased first cost, but it will often be found advisable to use a lesser ratio for practical reasons, as the slight loss in power will be offset by the greatly reduced first cost.

RATIOS OF STEAM CYLINDERS OF DIRECT-ACTING PUMPS.

Compound $R = \sqrt{\frac{P}{B}}$; Triple Expansion $R = \sqrt[3]{\left(\frac{P}{B}\right)^2}$

$R = \frac{\text{Low-press. Area}}{\text{High-press. Area}}$; $R_1 = \frac{\text{Int. Pr.}}{H.P.} = \sqrt{R}$

STEAM PRESSURE IN BOILER—GAGE PRESSURE.	ABSOLUTE INITIAL PRESSURE. P	COMPOUND.		TRIPLE EXPANSION.	
		Non-cond'g.	Cond'g.	Non-cond'g.	Cond'g.
Back Pressure.	$B=$	16	6	16	5
50	60	$R=$ 1.93	3.16	2.41	5.24
60	70	2.09	3.42	2.67	5.81
70	80	2.24	3.65	2.92	6.35
75	85	2.31	3.76	3.05	6.61
80	90	2.37	3.88	3.17	6.87
90	100	2.5	4.0	3.39	7.37
100	110	2.62	4.0	3.62	7.85
110	120	2.74	4.0	3.83	8.32
120	130	2.85	4.0	4.04	8.78
125	135	2.91	4.0	4.15	9.00
130	140	2.96	4.0	4.25	9.22
140	150	3.06	4.0	4.45	9.66
150	160	3.16	4.0	4.64	10.0
160	170	3.26	4.0	4.83	10.5
175	185	3.4	4.0	5.11	11.1

A chimney 506 feet tall, or 46 feet taller than the highest chimney now in existence, is to be built at the Boston & Montana Smelter, Great Falls, Mont.

Inexpensive Devices for Prevention of Fly-wheel Wrecks

By E. E. Clock

He who takes a "gambler's chance" involving human life, because it is easiest to follow along lines of least resistance, is not faithful to his trust. Often a man in charge of an engine thinks that if it was originally built without a safety-stop, yet is well along in years and has not run away, it is not for him to provide means to prevent the possibility of such accident. He is taking a gambler's chance.

The engine without a safety-stop but with a regulator, or governor, is exactly the same as a boiler which has no safety valve but is equipped with a damper regulator. The one keeps the speed from becoming dangerous by cutting off the steam, the other keeps the pressure from becoming dangerous by cutting off the draft. If the regulator on the engine should fail, there is always sufficient energy held back by it to cause a serious wreck and consequent loss of life and property, the prevention of which is much more difficult and dangerous than would result from the failure of a damper regulator, because in the case of the engine, the accident would result immediately, while the boiler would require considerable time to overload itself to the point of destruction.

We often hear it said that the engine is loaded down so that it could not run away even if the governor did fail. But as a rule governors do not fail at those times; the failure is usually due to a sudden increase in speed caused by all or part of the load being suddenly thrown off by the breaking of a shaft, clutch or main belt, often leaving the engine with only the crank-shaft to turn and no governor.

When the load is suddenly thrown off the engine must quickly increase its speed in order to bring about a shorter cut-off to meet the new conditions. In making this unexpected increase in speed, it must also suddenly accelerate the speed of the governor. Now, Corliss governors are usually massive affairs and to overcome suddenly the inertia of the balls brings a severe strain on the belt, consequently it would be better if all Corliss governors were provided with 100 per cent. more belt capacity than is now the practice.

The up-to-date engine builder is beginning to realize the necessity of a reliable safety-stop and many ingenious methods are employed. The latest and most efficient is the extra governor and extra cam, or cut-off collars: the extra cam blocks being put out of the way of the crab-claw, except when the speed is increased a predetermined amount.

However, every man who is responsible for the safety of his engine fly-wheel and those in its path should see that his engine is equipped with a safety-stop, or governor stop, so called. It is little short of criminal to operate an engine with nothing between him and a wreck but a narrow governor belt, when for an outlay of less than ten dollars he can provide a safety device such as is shown in Fig. 1. This is so plain as to need no description, except to point out that the pin in the governor standard, which releases the lower end of the governor rod, should be tapered in, loosely, so it can be taken out when shutting down and replaced again after starting; also, the stop clamped on the rod itself should be adjusted so as not to allow the spring to pull the bell crank too far up.

Fig. 2 shows how to provide a safety-stop or idler device for engines that have been equipped with a stop, but which are so loaded down at times that they are liable to shut down under load, and so the safety pin or collar must always be left in. This method leaves the pin in at all times, except when the governor belt fails and pulls it out of the way. The idler arrangement may be placed around the other way with the wheel near the governor pulley, or, if the eccentric rods are in the way, it may be applied to the bottom stretch of the belt on a balanced frame built on the tip-up principle: thus, if the engine is running "over," it acts as a binder pulley, being on the slack side of the belt.

Fig. 3 is an electric stop, which can be operated by speed-limit and push-buttons and can be installed for about 10 per cent. of the cost of some of the more elaborate methods, of which there are several on the market.

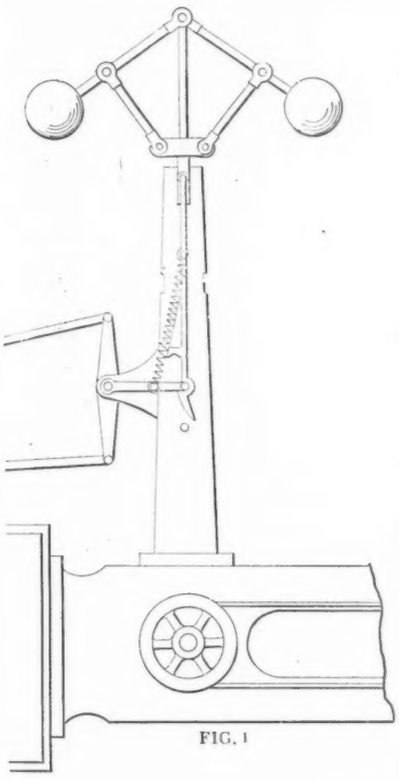


FIG. 1

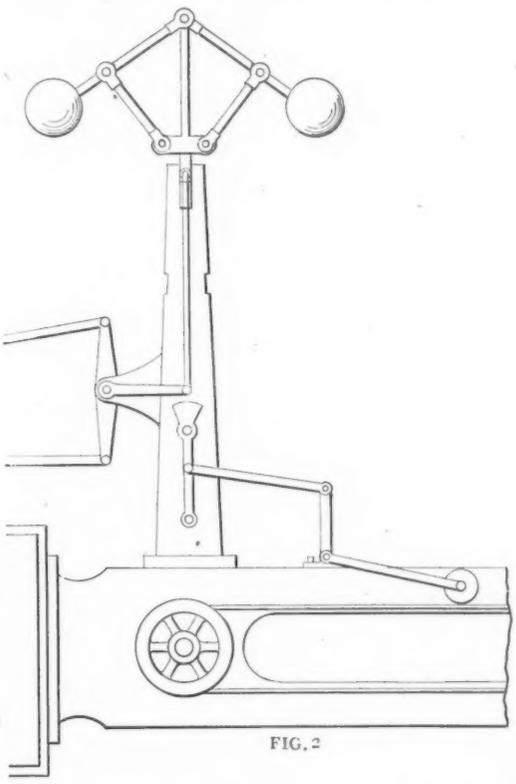


FIG. 2

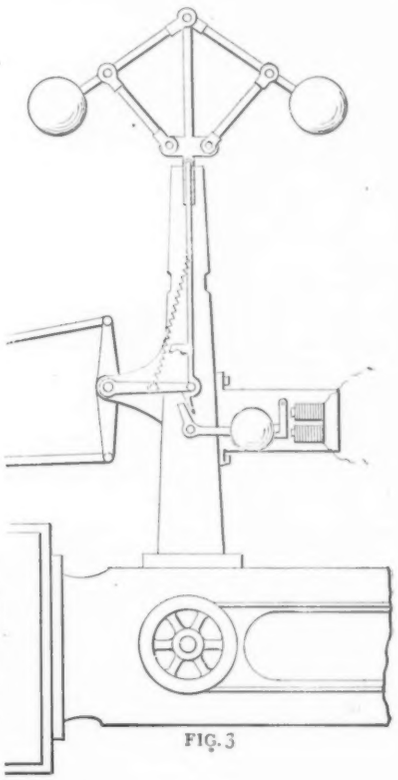


FIG. 3

INEXPENSIVE SAFETY DEVICES FOR THE PREVENTION OF FLY-WHEEL WRECKS

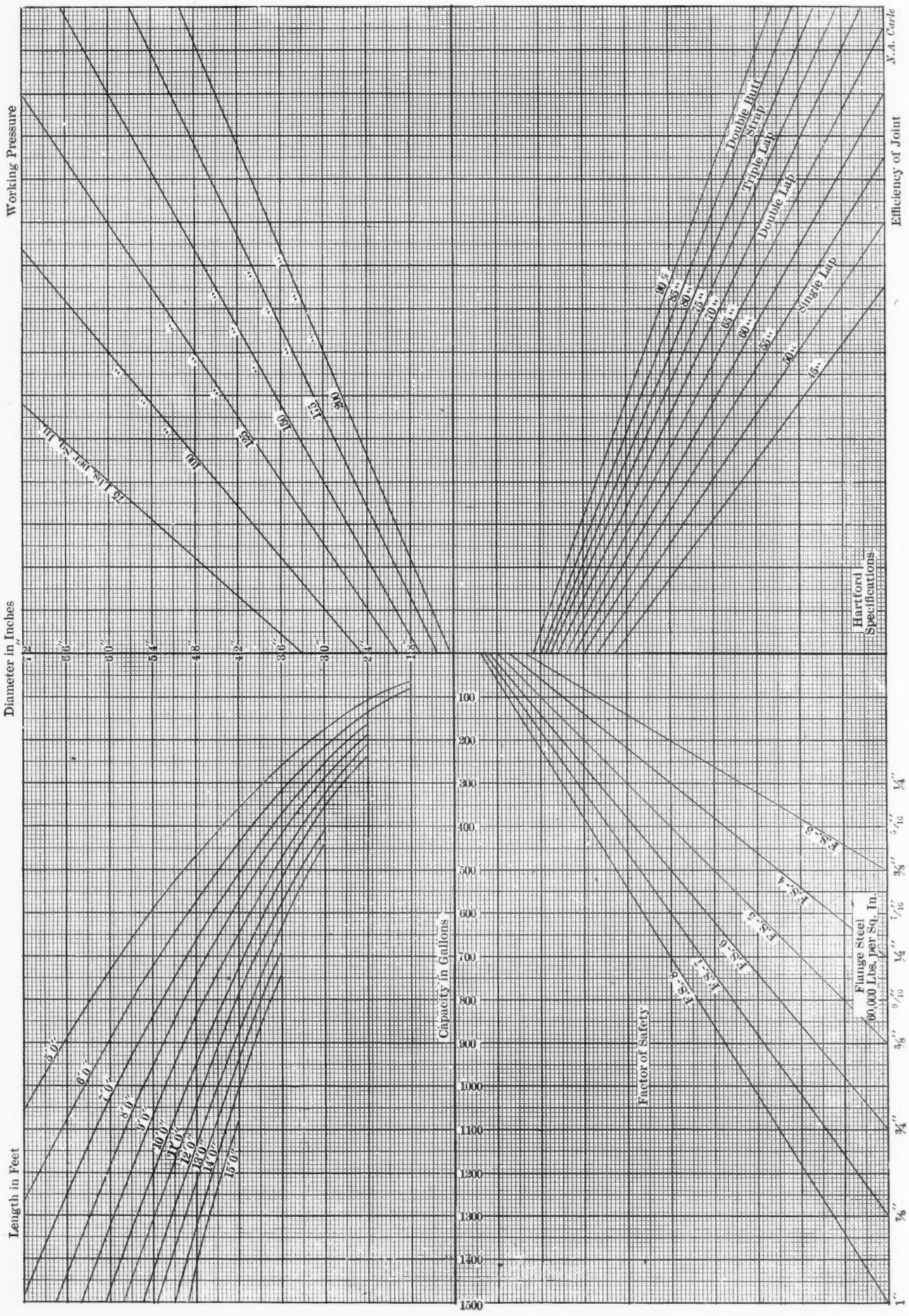


CHART OF DIMENSIONS FOR THE DESIGN OF PRESSURE TANKS

Pressure Tanks

By N. A. Carle

The capacity of pressure tanks is usually given in gallons and it is necessary to determine the proper diameter, length of tank and the thickness of plate required. The usual sizes range from 18 to 72 inches diameter and from 5 to 15 feet in length, designed for working pressures of from 75 to 200 pounds per square inch. The ratio of diameter to length usually varies between 1 to 3 and 1 to 5.

The thickness of plate depends upon the diameter of the tank, the working pressure, the efficiency of the riveted joint and the factor of safety desired. These quantities are independent of each other, although it is found to be good practice to have a certain relation between the *kind* of riveted joint and the working pressure. With these determined and a factor of safety selected, the thickness of the plate will vary with the diameter of the tank. It is therefore essential in designing a tank to get as small a diameter as will give a length consistent with the clearances available. The heads of tanks are usually dished and flanged, in stock sizes, in multiples of 6 inches, so that it is desirable to select one of these sizes in designing the tank.

The chart on page 452 is designed to determine directly the diameter and length of tank for any specified capacity up to 1500 gallons, and the thickness of plate to be used for such a tank under working pressures of from 75 to 200 pounds, with a factor of safety from 3 to 8, using joint efficiencies from 45 to 90 per cent. The efficiencies of joints vary only slightly in the practice of the various boiler shops. This is due to the requirements of the insurance companies giving a uniformity to the type and efficiency of the joints for different pressures and thicknesses of metal. The standard generally accepted is that of the Hartford Steam Boiler Insurance Company's specifications. The type of joint for the different efficiencies for Hartford specifications has been indicated on the chart.

Example

What thickness of plate should be used in designing a 1,100-gallon tank for a working pressure of 100 pounds per square inch, with a factor of safety of 5?

Starting with 1400 gallons, and selecting the smallest diameter shown on the chart, it is found that a 48-inch diameter 15-foot tank will give the desired capacity. For 100 pounds working pressure use a double lap-riveted joint with an efficiency of 65 per cent. Then, starting with a 48-inch "Diameter," read across to 100 pounds "Working Pressure," then down to 65 per cent. "Efficiency of Joint," then over to 5 "Factor of Safety," and down to 5/16-inch "Thickness of Plate."

Changing from Wood Fuel to Crude Oil

By J. E. Anderan

Some time ago I was called upon by an irrigation company to change the boilers of a pumping plant to burn crude oil instead of wood. The pumping station was located on a river bank and consisted of two 16x36 releasing-gear engines, belted to Morris centrifugal pumps. The lift and head together was 42 feet at low water, and about 39 feet at high water. There were four boilers, 60 inches diameter and 16 feet long, of the return-tubular type. The furnaces were built especially for wood, but the settings were in good condition.

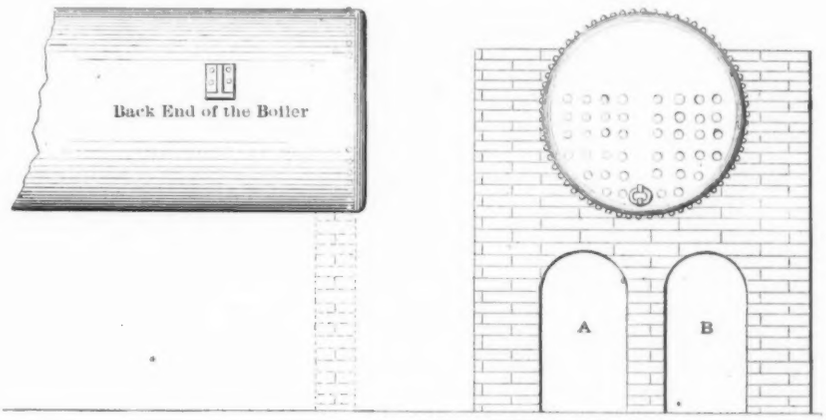


FIG. 1. SHOWING THE "RETAINING" WALL

This plant at full load developed about four hundred indicated horse-power, depending on the lift of the pumps, and it required an average of 32 cords of wood every 24 hours. The wood was delivered at the plant at $1.50 a cord. There were two firemen and one roustabout. The firemen were paid $1.75 each for 12 hours' work, and the roustabout $1.50. The total fire-room expense was $57.80 for each 24 hours. It was hard to get firemen for this place; in fact, sometimes $3 a day would hardly induce them to work. The temperature was high and the work hard. Besides that, there was only one white man (the chief engineer) on the place, the rest being negroes.

The fuel oil was to be shipped in on barges, so I had to look for a suitable place for fuel-oil storage. I found a level space about 80 feet from the pumping station, and here I put the scraper to work and dug a hole 20x40 feet, by 10 feet deep. This was walled with lumber and roofed over. It is a very crude affair, but cheap, and answers the purpose.

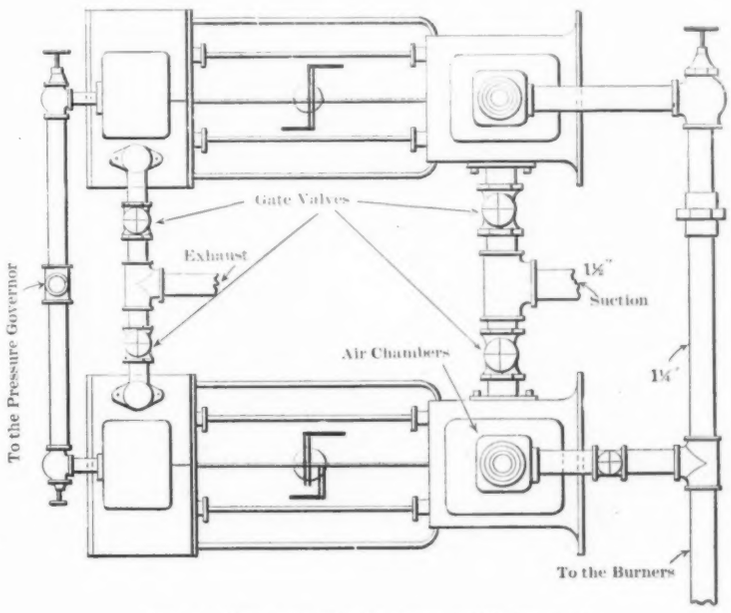


FIG. 2. HOW THE PUMPS WERE CONNECTED UP

As the furnaces were designed to burn wood, the bridge wall and the grates were too near the boiler for burning oil fuel, on account of the danger of burning or blistering the sheets. I lowered the grates one foot, locating them 30 inches from the boiler, and the bridge wall was low-

ered to give 18 inches of clearance under the boiler.

Next I made what I call the "retaining wall," as shown in Fig. 1. Some engineers will look at this with suspicion, but it is all right and saves fuel. The openings *A* and *B* are each about the area of

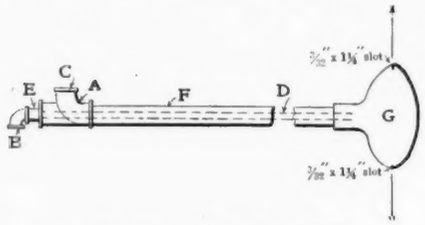


FIG. 3. DETAILS OF BURNER

the smoke stack for one boiler. The grates were covered with clay, except in front, where I left a crosswise space about 8 inches long, to admit air to the burner. For pumping the fuel two 3x2x3 Snow duplex pumps, with metal valves, were procured and connected up, as shown in Fig. 2, with a foot-valve on the end of the suction line. The holes in the strainer were ½ inch in diameter. Many engineers get in trouble with the fine strainers that are generally used; such strainers clog, but I have used fuel oil for five years without trouble of that kind. Heating the coils in the storage tanks is another unnecessary expense. For one thing it is not required, and then again common pipe does not last more than a year or two, the pipe becoming corroded until it is like a sieve. To be sure, some oil is very thick, but none is so thick that a good pump will not handle it.

The pumps were placed side by side on a brick foundation with galvanized pans underneath. The pans were piped to a main running back into the tank. The vent pipe or opening from the pumping end of the pump was also connected to this pipe. By this means a little water

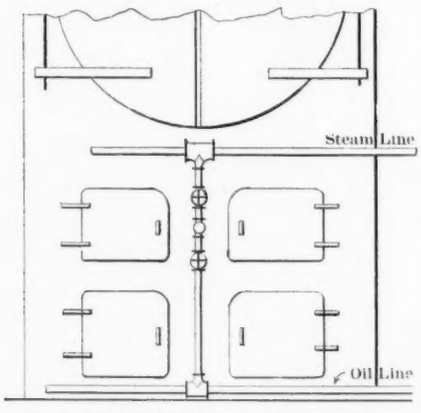


FIG. 4. ARRANGEMENT OUTSIDE OF BOILER

may get into the storage tank from the stuffing-boxes on the steam end of the pump, but not enough to interfere with the burners. The burners (see Fig. 3) were of my own design. Referring to the sketch, *A* is a a long sweep tee, ½x¾x½; *B* is the oil inlet, *D* a ¾x¼-inch pipe connected to the close nipple *E*, and *F* is a ¾-inch pipe connected with the steam end. The steam surrounds the oil pipe *D* and heats the oil before it gets to the sprayer *G*. This sprayer, unlike the ordinary type, puts the fire right and left, and the highest temperature is on each side of the boiler in the center of the fire sheet. I find this very important, because it takes advantage of the full length of the boiler. The fire starts at the very front, same as a coal fire. Also, the fire is sent where it is wanted, on the side of the boiler. Fig. 4 shows the general arrangement on the outside of the boiler. It will be seen that the burners will not interfere with using wood or coal as fuel. This is a great advantage for a plant that does not have steam up all the time, because it is necessary to have steam before the crude oil can be used. Some plants use a small boiler for this purpose only, but this expense is not necessary if the arrangement is as in Fig. 4. One boiler can be fired up with wood until the gage registers about 30 pounds. Then the oil pump can be started and all the boilers can be supplied with crude oil and steam.

In starting an oil burner, light a handful of waste or take a torch and put it underneath the burner. Then turn on a little steam, enough to make it blow through the slots, and gradually turn on the oil. This rule applies to all burners and should be strictly followed; if not, accidents will happen. And, too, more oil means more steam, and *vice versa*. It is always advisable to turn one's face away to one side until the oil ignites, because it ignites with an explosion, if it is not handled properly, and many a man has got a clean shave in a mighty short time through neglecting this caution. I have known of plants where even boiler walls have been thrown out by oil explosions at the hands of careless firemen.

After getting the burners in, I remained a while to see the results. At the end of the week it was found that the fuel consumption averaged 69 barrels of crude oil per day of 24 hours; the oil cost 60 cents a barrel delivered at the plant. There were two firemen (one day and one night), each getting $1.75 for 12 hours' work, so that the total expense in the fire room was $44.90, against $57.80 before the change, or a saving of $12.90 every 24 hours.

There are several crude-oil fuel systems on the market, at more or less fancy prices, but they do not work any better than this one, and any engineer can install mine if he knows how to fit pipes.

Gas generated in a producer, without the use of steam, has a thermal value of about 70 British thermal units per cubic foot. By using steam with the air admitted to the fire, the producer gas generated will immediately have a thermal value of from 135 to 140 British thermal units per cubic foot.

"A Question in Belt Operation"

By J. W. Taylor

R. T. Strohm stirred up considerable comment by his "Question in Belt Operation." I think a further discussion of the question would be profitable, and would like to give my explanation of the operation.

Question: Shaft *A*—*B* inclines toward *C*—*D*, as in Fig. 1. At which side of the pulley will the belt run off? Referring to Fig. 1, *H* is the high side and *I* the low.

The prevailing answer seems to be that practically the belt will run off at *I*, although theoretically it should run off at *H*. The answer is right and wrong.

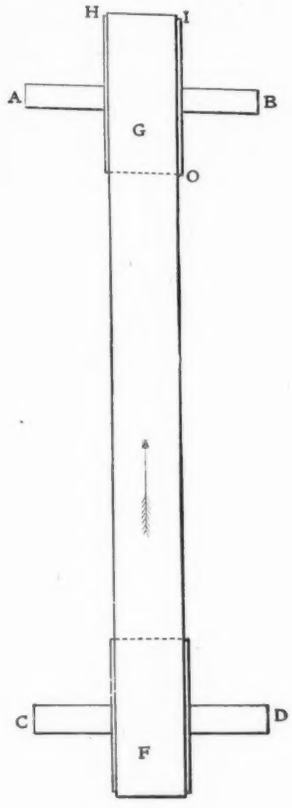


FIG. 1

Theory that is not consistent with practice is not true theory. Either the one or the other is wrong, if the two cannot agree. We know from experience that the belt will run off at *I* in practice. Why will it not do so in theory? It surely will, and must, if our theory is right.

The friction between the belt and pulley tends to make the two move together. That means that every point on the surface of the belt tends to stay on and follow every point on the surface of the pulley with which it comes in contact. In determining then which way a belt will run off, two things must be clear in mind: First, the position the belt takes on, or clings to, the pulley, and, second, the direction in which the surface of the pulley moves. A few special cases will help to clear up the subject.

Take, first, a cone pulley. Fig. 2 shows in an exaggerated way the condition of a belt on a cone. All points on the surface of the pulley move in a direction at right

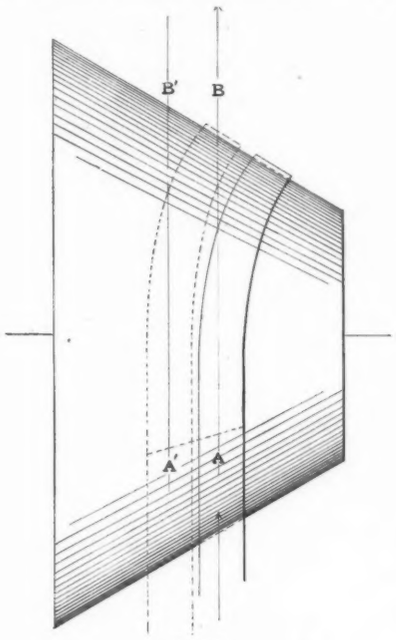


FIG. 2

angles to the shaft or axis. Follow the action of any point on the belt. For convenience take *A*, at the center of the belt and on the line of contact. The point on the pulley underneath *A* tries to carry *A* to *B*. With the center of the belt at *B* the belt takes the new position shown by the dotted lines and the center of the belt on the line of contact is now at *A'*, and *A'* in turn is taken to *B'*. The operation continued further in a similar manner carries the belt off at the large diameter. Of course this shifting of position is gradual and continuous, as if the belt were following a spiral.

The stiffness of the belting gives it the curved form represented in Fig. 2. If, however, the cone's taper is small enough and the belting flexible enough to give the

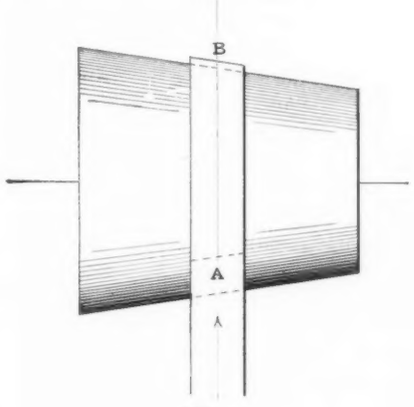


FIG. 3

belt the hang shown in Fig. 3, it will not attempt to climb.

Fig. 4, also an exaggerated sketch, shows the condition of a belt on a cylindrical pulley with its axis inclined to the line of drive. Though the conditions are altered, the principle here is the same as with the cone. The point *A* is carried to *B* and the belt takes the position shown by the dotted lines, while *A'* is carried to *B'*, and the belt finally runs off the pulley at the low side.

Fig. 5 illustrates how readily a belt will run off a cylindrical pulley with an inclined axis when it is possible for the belt to hang without transverse curvature.

With a crowned pulley in a normal position the center of the crown takes the belt first and leads it in a central, balanced position. If the belt ever starts for one side or the other, it immediately takes a curved position and is quickly brought back to the center, or the highest

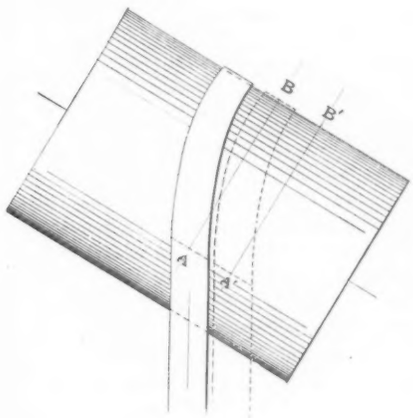


FIG. 4

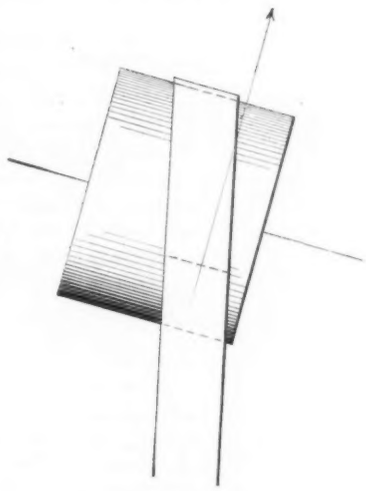


FIG. 5

point of the cone (Fig. 2). The greater linear velocity of the larger diameter has nothing whatever to do with this.

On a cylindrical pulley with an inclined axis the belt will never run off the high side, unless other conditions than the mere inclination of the pulley enter the case. It makes no difference which side, high or low, first comes in contact with the belt, for both sides are moving in the same direction and are carrying the belt out of the line of drive toward the low side. See Figs. 4 and 5.

When the two sides of a belt are unequally stretched, it tends to run off on the loose side. The cause is clearly shown in Fig. 6. This figure is lettered and read as in Fig. 2.

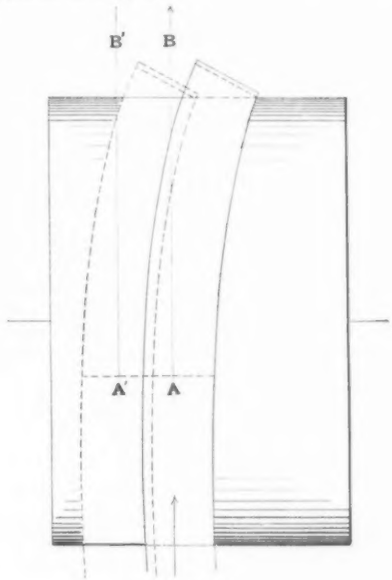


FIG. 6

On a cone or an inclined cylinder the more flexible the belting the nearer the center of the arc of contact the transverse curvature takes place. Naturally the stiffer the material the farther away and more extended is the curvature, so that the conditions on a cylindrical pulley can be such that the belt will run on to the wheel in a direction parallel to the direction of rotation, even though inclined to the line of drive. This is shown in Fig. 7, and this

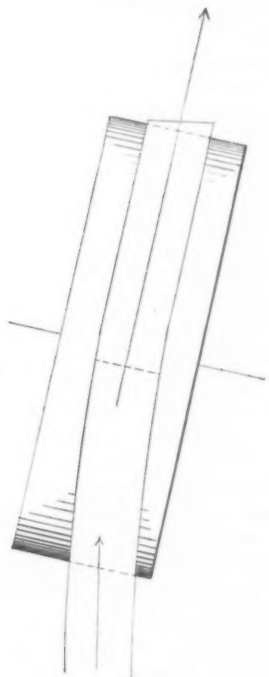


FIG. 7

is the condition of the band-saw. The tension on the band and the inclination of the pulley can be readily adjusted to clear the teeth from the wheel and still keep the saw in place.

How Should the Feed Water Be Heated?

A Discussion of the Best Known Methods; and Formula for Calculating the Saving by Heating with Exhaust Steam

BY A. J. ALBRIGHT

It must be done. This much is conceded by everyone. But how? That is the question. There are in general three ways of heating the water, and no one method is best for all conditions. The first method, and the one most largely used, is to heat the water with exhaust steam or steam partially expanded. Another method is to extract heat from the waste gases of the furnace and use it to raise the temperature of the feed water. The third method is the use of live steam direct from the boiler to supply the heat.

It is in the application of this latter method that the inexperienced man is likely to go astray. No argument is necessary to show that the heat recovered from exhaust steam or the waste gases is a direct saving; but in the case of live-steam heating, the way in which a saving is effected is not so obvious. At first thought it would seem that there could be little chance of economizing by taking heat out of the boiler, juggling it around through a system of piping and then returning it again to the boiler One would naturally think that there would be a loss from such a process by radiation of heat, if in no other manner. Indeed, there is such a loss, and it is up to the engineer to find a benefit that will more than overbalance the loss.

That there is economy in heating with live steam, under the proper conditions and with the proper apparatus operated rightly, is a fact that has been demonstrated time and again. There are two reasons why this is true, the one being the fact that the circulation of the water in the boiler is not checked or impeded where the hot water is used, as is the case when cold feed water enters the boiler. The other reason lies in the fact that the water, when heated, deposits the mineral matter and other foreign substances carried in suspension, leaving them behind in the heater. The exhaust steam does not often heat the water hot enough to cleanse it thoroughly of all the impurities, so that in many cases where exhaust steam is used for heating the feed water live steam may be used to advantage in raising the temperature beyond the point that would be possible with the exhaust steam alone, and thus completing the work of purification that was begun by the heating effect of the exhaust steam at the lower temperature.

Much will depend, however, on the condition of the water. The temperature must be higher for precipitating some minerals than for others, and it may be in a certain case that practically all the mineral matter can be got rid of at the lower temperature due to the exhaust steam. If this is the case, it would be folly to use live steam for heating the feed water to a higher temperature, unless the exhaust is at so low a pressure that the heat is not enough to heat the water sufficiently to keep it from checking the circulation when it enters the boiler. Where the pressure of the exhaust steam is very low, the steam may not contain enough heat to make the installation of an exhaust heater and the appurtenances thereof a profitable investment. On the other hand, when an engine is not loaded to its full capacity, it may be best to increase the back pressure at the expense of engine economy so that the exhaust steam wll furnish the required amount of heat to purify the feed water and raise its temperature as required. In case this is done, the expense of the live-steam heater and its connections is done away with, and this is a great point gained.

Points to Be Considered

From this it will be seen that there are a great many points to be considered and one of the chief is the fact that, if possible, heat should be supplied from some source in sufficient quantity thoroughly to purify the water of all the contained mineral matter and foreign substances. No impurities should be allowed to find their way into the boiler if it can possibly be avoided, because the chief business of a boiler is to generate steam and not to heat and purify the water. Assuming that the steam is at atmospheric pressure, and a temperature of 212 degrees, it will hardly be possible to heat the feed water to a temperature higher than 208 or 210 degrees Fahrenheit, without incurring a penalty in the shape of excessive first cost for the apparatus. Although the rate at which water absorbs heat varies slightly as the density decreases, it may safely be assumed that the number of degrees Fahrenheit that the temperature of the water rises upon an application of heat is the same as the number of British thermal units that have been absorbed.

Taking steam at 160 pounds gage pressure, the temperature is 370 degrees Fahrenheit, and if the feed water is at a temperature of 70 degrees, each pound of the water must absorb 300 units of heat before it can be converted into steam, or be ready to be evaporated. In addition to this there is the latent heat that must be supplied, and this will be 851.7 units, so that the total heat needed is 1151.7 units and the 300 units represent about 26 per cent. of the total heat needed. All of this heat can be applied to the feed water, but not with exhaust steam. It will thus be seen that the maximum percentage of saving that may be had by heating feed water for steam at this pressure is about 26 per cent. With exhaust steam, the saving by heating the feed to 208 degrees would be about 12 per cent. for this case.

Another way of looking at the saving effected by heating with exhaust steam is to consider engine economy. In the best engine yet designed, not more than one-fifth of the heat contained in the steam is utilized, owing to the fact that much of the latent heat is necessarily rejected without doing work. By heating feed water with the exhaust steam, it is possible to return the latent heat of as much steam as the feed will condense to the boiler, except that lost by radiation. The actual saving will depend on the steam pressure, and the pressure of exhaust and will be found to vary between the approximate limits of 10 and 15 per cent. The saving in any case may be figured by the formula:

$$S = \frac{100\,(t - t')}{H + 32 - t'},$$

where t = the temperature of the water in degrees Fahrenheit after heating,

t' = the temperature before heating,

H = the total heat in British thermal units above 32 degrees Fahrenheit per pound of steam,

S = the saving in per cent.

The methods of applying the formula to obtain the curves of per cent. saved, etc., will be shown presently.

It is often the case that the exhaust steam can be used to more advantage for heating buildings, drying rooms, etc., than for heating the feed water, and when this is the case it will be necessary to heat the water by live steam, or by economizers that save heat that would otherwise go to loss in the waste gases. These will be treated later, but for the present it will be necessary to show how the heating is to be done with live steam.

Types of Heaters

There are in general two types of heaters for use with steam whether it be live or exhaust, these being the open and the closed forms. In the open heater the steam mingles directly with the water and condenses to form part of the feed supply to the boiler. In the closed type the steam is kept separate from the water by being passed through a pipe coil placed in the tank that contains the water. It is then necessary to decide which form of heater is best adapted to the conditions in force at the given plant.

Where the steam contains considerable oil or other impurities, it will be necessary to have exhaust-steam purifiers and oil filters to clean the steam, if it is to be used in an open heater. This means an expenditure of money on which the plant will have to earn an income. On the other hand the open heater utilizes the water, except so much as may go to waste, and this is often a big item where the water has to be purchased by the meter system. Then again, the open heater is constructed to take care of the impurities that are precipitated by the heat, being so made that these are deposited where they can readily be removed when cleaning day comes.

The closed heater is not adapted to dirty feed waters, as the precipitates from the water soon coat the coils or tubes so as to impair the efficiency of heat transmission, and heater coils are difficult to clean. Oil in the steam, making necessary the use of the closed heater, will form a coating on the inner surfaces of the coils and thus reduce the efficiency.

It is evident, therefore, that the conditions are somewhat conflicting. Where the water contains a large amount of mineral matter and there is oil in the steam, it will probably be best to install an open heater in connection with an apparatus for purifying the steam before it gets to the heater. This will make a costly installation; but it must be remembered that the closed heater costs a good deal on account of the expensive pipe coils and connections.

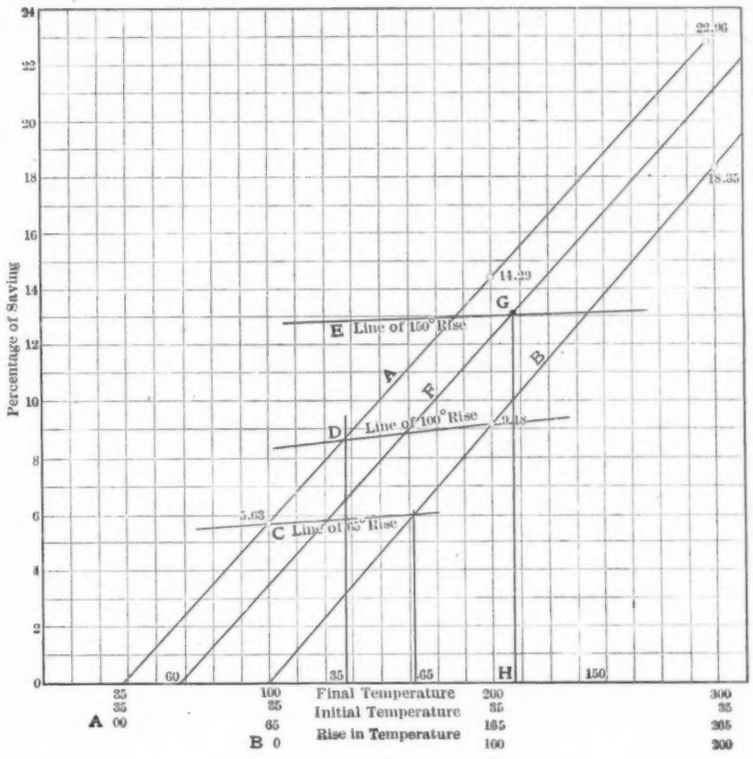


FIG. 2

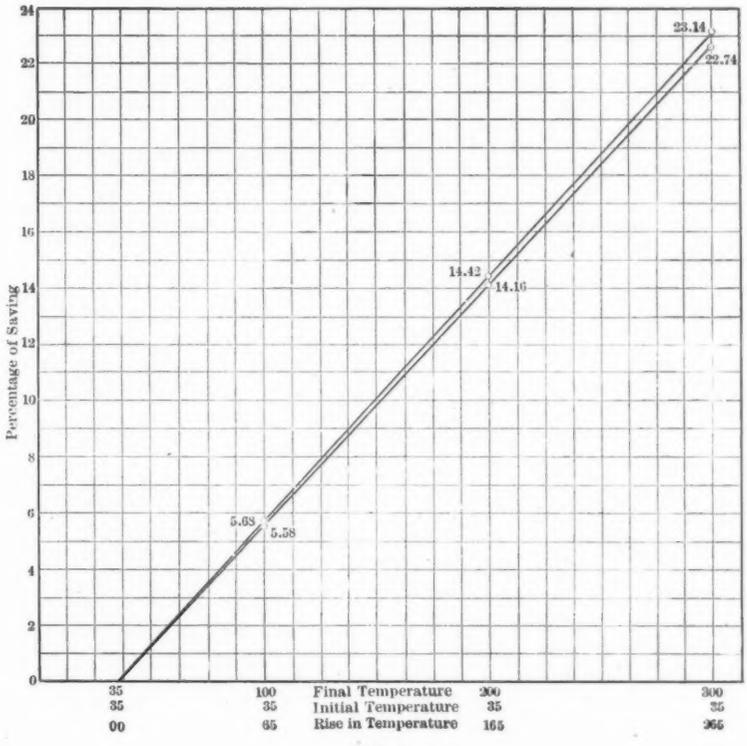


FIG. 1

The Use of Fuel Economizers

Fuel economizers are constructed in different ways, but each of them consists of a system of pipes through which the water passes while the gases surround the outside of the pipes on their way to the uptake. The apparatus is necessarily large and heavy, so that it takes up a comparatively great amount of floor space and requires an increased outlay for constructing the brick setting or purchasing a metal housing. The apparatus is also likely to have its operation impaired if the water is dirty and deposits scale or sediment on the inner surfaces of the pipes. Still, economizers when properly constructed and adapted to the plant where installed are capable of effecting economies that in many cases cannot be had in any other way.

If the water is not reasonably clean, means should be provided for heating it or for cleansing it with compound in water-softening apparatus. If it is heated with the exhaust steam, as can be done in some cases, the economizer will have to add only the heat necessary to raise the temperature of the water above what can be had with the steam. Care must be taken, however, or the margin left for the working of the economizer will not enable it to do enough good to pay the interest on the investment. In general it may be said that the higher the efficiency of the boiler and the other apparatus of the plant, the smaller the opportunity for an economizer to show a net saving. In the

case of a boiler having 80 per cent. efficiency, the margin left for the working of the economizer would be too small to warrant the installation unless the case was very exceptional. Tests made by Clark have shown that under certain conditions the Green economizer showed 9 per cent. increased rapidity of circulation with a 10 per cent. increase in general efficiency.

In using the economizer, it must be remembered that the temperature of the gases cannot profitably be reduced below a certain point. As the intensity of the draft depends in a great measure on the difference in temperature between the gases inside the chimney and that of the air outside, it follows that by reducing the temperature of the gases in the uptakes the intensity of the draft or the draft power available is also reduced. On the other hand, the boiler, being supplied with feed water at a higher temperature, will need to burn less coal for the same amount of water evaporated, so that, on the whole a considerable economy may be had. It will be apparent, however, that the extent to which the temperature of the gases may be lowered is a variable quantity and depends upon the draft power required to consume properly the fuel on the grates. There is, therefore, a maximum temperature of feed for each case, beyond which we cannot go without extracting so much heat from the gases as they pass through the economizer that the draft and, therefore, the efficiency of the boiler will be impaired.

In heating feed water by any process, the main gain is had by supplying heat to the water before its temperature has risen to that at which evaporation takes place under the given pressure. On this account, differences in pressure have little effect on the amount of the saving had by heating the water. This fact is clearly shown in Fig. 1, in which the vertical distances represent the per cent. of fuel saved by raising the temperature of the feed water from an initial temperature of 35 degrees to the final temperatures as laid off on the horizontal base line of the figure. If we start with the 35-degree point on the base line as the origin, the distances measured to the right will represent the rise in temperature for the different cases. The figures of this are seen in the lower line, the formula for the figuring being that given above.

It should be noted that the quantity H in the formula is the only factor affected by the boiler pressure, and this only in small degree, as may be learned by consulting the steam tables. It will be noted in the table, for instance, that the heat in steam at 75 pounds pressure is 1179.5 British thermal units, while at a pressure of 200 pounds it is only 1200.2 British thermal units, or a difference of 20.7 units for the difference of 125 pounds in pressure.

How to Apply the Formula

To construct the line in Fig. 1, calculations of the fuel saving are made for different assumed conditions of pressure and temperature; thus, for a final temperature of 100 degrees the per cent. of saving by the formula is $100\ (100-35) \div 1179.5 - 35 = 5.68$. This per cent. is laid off to the scale of the diagram on the vertical line at the left of the figure. Since the value of H taken in this case is that for 75 pounds pressure, the horizontal line drawn from the point 5.68 to intersect the vertical line drawn from the point on the horizontal base line corresponding to a final temperature of 100 degrees gives at the point of intersection with this line one of the points on the inclined line of saving. In a similar way the value of H for 200 pounds pressure is taken, and the per cet. of saving (5.68) is figured, thus determining a point on the line of saving for this pressure. Other savings are figured by the same formula. It is seen that the two lines lie close together, thus showing the small effect of pressure on the saving had by heating feed water.

Fig. 2 shows lines of saving similar to those of Fig. 1, with the exception that an average pressure of 125 pounds is used for all cases. Taking an initial feed-water temperature of 35 degrees Fahrenheit with this pressure and, by means of the formula, figuring the percentages of saving in the manner just described, the inclined letter A at the left of the figure is plotted and drawn. This done, the line B is drawn with the same pressure and an initial temperature of 100 degrees for the feed water, which temperature probably represents the maximum ever met with in practice. It will be seen that the two lines A and B are not parallel but converge slightly, thus showing that for some temperature outside the range of possibility they will meet.

In the third and fouth rows of figures at the bottom of Fig. 2 the rises in temperature from the origins of 35 and 100 degrees are given. By laying off on the horizontal line at the bottom distances corresponding to any given amount of rise, and erecting perpendiculars to the base line at the points thus determined, the points of intersection of these perpendiculars with the lines A and B will be two points on a straight line which is slightly inclined to the horizontal and will show the saving effected by heating the water to the given amount of rise from different initial temperatures. It will be noted that the saving increases as the initial temperature becomes greater, the rise being constant at all times. Line C shows this fact for the rise of 65 degrees, while line D shows the saving for a rise of 100 degrees and the line E that for a rise of 150 degrees. Taking the average initial temperature of 60 degrees, the line F is constructed in the same manner as the lines A and B, and the point G where it intersects the line of 150-degree rise should, if the diagram is correct, correspond to a final temperature of 210 degrees on the horizontal base line. By dropping a perpendicular from the point G to the base line, it is found to intersect this line at the point H, which shows a final temperature of 210 degrees and proves that the diagram is correct. Measurement of the line G—H to the scale of the diagram shows a saving of 13.4 per cent., which is the amount of fuel that should be saved by heating the feed water from a temperature of 60 degrees to a final temperature of 210 degrees, as would be done if exhaust steam was used.

Reciprocator or Turbine, which Is the More Efficient?

By Edward Russell

There is a great deal of literature which treats of the high efficiency of steam turbine plants, but in reality, when reciprocating engines and turbines are closely compared, one does not appear to be greatly in advance of the other; in fact, looked at in the manner indicated below, the turbine is inferior to any high-grade make of reciprocating engine.

In a turbine, of course, the only loss due to mechanical friction occurs in the bearings, with a small additional amount in the oil-pump gear, if it supplies its own oil; while in a reciprocatory engine there is, besides piston friction, the friction of valves, glands, guides, connecting-rods, eccentrics and crank-shaft bearings, all of which require a certain amount of power to cause them to perform their required movements. Yet, the steam economy is the same in both cases, although the turbine has one or two inches more of vacuum. It appears, then, that either a great deal of steam leaks through the turbine without doing any work, or else the skin friction of the rotor is far greater than supposed. It is granted that the turbine gives more horse-power per square foot of space, and calls for a smaller bill for repairs when in proper running condition.

In the matter of foundations, the turbine will require a little less than a good make of high-speed engine, but the foundation must be stiff, or else warping of the machine, which will most likely lead to the stripping of the blades, may result. Whether the turbine requires less looking after when running is another point which is hard to decide, for a high-speed engine equipped with a good governor needs very little supervision; in fact, almost less than a turbine, and in reality there is not such great danger of pistons becoming loose, etc., as the turbine man would have us believe.

Suppose the plant is operating with very bad water carrying a large amount of deposit; which is the cheapest—especially if you cannot afford a shut-down—to fit a new piston ring in the engine, or remove a turbine cover and spindle for a few days while the blades are being cleaned? The latter is necessary in some places, unless one is willing to have the machine reduced in power; whereas in the reciprocating engine the rings would have to be in a very bad state to cause the machine to lose power. Of course, with the turbine plant there is no cylinder-oil in the feed-water, or in the works costs, unless there are reciprocating auxiliaries, whereas in a modern high-speed reciprocating plant cylinder-oil is an important item.

The first costs of the two plants will not vary greatly. The turbine room will be cheaper on account of the hight being less, but as a rule this is not studied. A turbine can, of course, be put into a space where the head-room would not permit o an engine installation.

Vibration in a turbine can be brought down to such a point as to be unnoticeable, whereas in the high-speed engine it can always be felt more or less. The generator, if a direct-current machine, will require more attention in the turbine set.

In starting up, the turbine will be found to be more convenient in five out of six cases, as there is no fear of valves sticking, or of water getting in the cylinder, but a strong point in favor of the reciprocating engine is that it can be stopped in a very short space of time, whereas the turbine will run anywhere up to 40 minutes after the steam is shut off, except certain Curtis turbines which are fitted with magnetic brakes. Perhaps in the long run the turbine plant will be the cheaper of the two, unless a special blading staff has to be maintained.

The Steam Engine versus the Gas Engine

One of the features of the Dayton meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers was a discussion of the relative merits of the steam and gas engines. The statement of the question included and put especial stress upon the use of the exhaust for heating, and the papers dealt with that phase of the subject, but the discussion ran more to the dependability and mechanical fitness of the newer type of motor for exacting service.

F. W. Ballard, secretary of the society, presented an academic consideration of the subject, showing that, although the gas engine was the more efficient heat motor, the steam engine had the advantage when the exhaust steam could be utilized for heating. The possibility of a similar use of the exhaust from the gas engine is limited, because of the low fuel consumption and the large proportion of the heat in the fuel which is converted into work. In the exhaust of a simple, non-condensing steam engine there are discharged per hour about 30,000 heat units for each horse-power, and this would supply about 90 square feet of radiation; the exhaust of a gas engine containing only about 6000 heat units per hour per horse-power, which would supply only about 20 square feet of radiation.

D. L. Fagnan told of a plant containing two gas engines, one of 9 and one of 30 horse-power, running 24 hours a day four months in the year and 12 hours a day the rest of the time; in this plant the average cost for the whole year was $200 per month. The fuel was illuminating gas at $1 per thousand cubic feet. With electric

COST OF 200 HORSE-POWER AND 1000 HORSE-POWER STEAM AND GAS PLANTS.

Assuming the 1000 horse-power engine is compound condensing and the 200 horse-power is a simple automatic cut-off engine; that the coal with steam plants and bituminous coal producer costs $2 per short ton, while anthracite is $4.50 per ton. Bituminous coal averaging 11,000 B.t.u. per pound and the anthracite 13,000 B.t.u., lower heat values.

	Load Factor.		Steam.				Producer Gas.							
							Bituminous.				Anthracite.			
			1000 H.P.		200 H.P.		1000 H.P.		200 H.P.		1000 H.P.		200 H.P.	
			Full.	50%	Full.	50%	Full.	50%	Full.	50%	Full.	50%	Full.	50%
1	Cost of engine per rated horse-power			18.00		14.00		40.00		44.00		40.00		44.00
2	Cost of piping per rated horse-power			6.00		5.00		3.50		3.00		3.50		3.00
3	Cost of condensers per rated horse-power			3.00		....		....		....		....		....
4	Cost of pumps, etc., per rated horse-power			0.50		....		....		....		....		....
5	Cost of air starting app. per rated horse-power			....		....		1.00		1.50		1.00		1.50
6	Total of engine plant			27.50		19.00		44.50		48.50		44.50		48.50
7	Depreciation, 4 per cent. on total			1.10		0.76		1.78		1.94		1.78		1.94
8	Repairs, 2 per cent. on total			0.55		0.38		0.89		0.97		0.89		0.97
9	Interest, 5 per cent. on total			1.37		0.95		2.22		2.42		2.22		2.42
10	Total of lines 7, 8, 9			3.02		2.09		4.89		5.33		4.89		5.33
11	Boilers per rated horse-power			10.00		12.00		....		....		....		....
12	Producers per rated horse-power			....		....		15.00		18.50		10.00		14.00
13	Chimneys and breeching per rated horse-power			7.00		3.50		....		....		....		....
14	Heaters, feed-pumps per rated horse-power			1.50		1.50		....		....		....		....
15	Auto. stokers or coal machinery per rated horse-power			5.00		....		2.00		....		2.00		....
16	Total of fuel plant			23.50		17.00		17.00		18.50		12.00		14.00
17	Depreciation, 8 per cent. on total cost			1.88		1.36		1.36		1.48		0.96		1.12
18	Repairs, 3 per cent. on total cost			0.70		0.51		0.51		0.55		0.36		0.42
19	Interest, 5 per cent. on total cost			1.17		0.85		0.85		0.92		0.60		0.70
20	Total of lines 17, 18, 19			3.75		2.72		2.72		2.95		1.92		2.24
21	Coal used in b.h.p.-hr. in lb		2.00	2.20	4.75	6.30	1.10	1.50	1.10	1.50	0.90	1.40	0.90	1.40
22	Cost of coal per b.h.p. per day of 24 hr.	Cents.	4.80	5.28	11.40	16.22	2.64	3.60	2.64	3.60	4.86	7.56	4.86	7.56
23	Attendance of engine b.h.p. per day of 24 hr.	Cents.	1.20	2.40	3.00	6.00	1.05	2.10	....	....	1.05	2.10	....	....
24	Attendance of fuel plant per day of 24 hr.	Cents.	0.65	1.30	1.75	3.50	0.75	1.50	3.75	7.50	0.70	1.40	3.75	7.50
25	Oil, waste and supplies	Cents.	0.50	0.80	0.50	0.80	0.50	0.70	0.50	0.70	0.50	0.70	0.50	0.70
26	Total daily expense per b.h.p. per 24-hr. day		7.15	9.78	16.65	26.52	4.94	7.90	6.89	11.80	7.11	11.76	9.11	15.76
27	Yearly oper. expenses 309 days per b.h.p., dollars		22.09	30.22	51.45	81.95	15.26	24.41	21.29	36.46	21.97	36.33	28.15	48.70
28	Cost of coal per b.h.p. per day of 10½ hr.	Cents.	2.05	2.25	4.86	6.46	1.13	1.54	1.13	1.54	2.30	3.58	2.30	3.58
29	Attendance of engine b.h.p. per day of 10½ hr.	Cents.	0.70	1.40	1.50	3.00	0.40	0.80	....	....	0.40	0.80	....	....
30	Attendance of fuel plant per day of 10½ hr.	Cents.	0.28	0.56	0.88	1.75	0.45	0.90	2.00	4.00	0.45	0.90	2.00	4.00
31	Oil, waste and supplies per day of 10½ hr.	Cents.	0.27	0.49	0.26	0.49	0.27	0.46	0.27	0.46	0.27	0.47	0.27	0.47
32	Total daily expenses per day of 10½ hr.		3.30	4.70	7.50	11.70	2.25	3.70	3.40	6.00	3.42	5.75	4.57	8.05
33	Yearly oper. expenses 309 days per b.h.p., dollars		10.20	14.52	23.17	36.15	6.95	11.43	10.50	18.54	10.57	17.77	14.12	24.87
34	Yearly expenses lines 10, 20, 27 = 24-hr. day		28.86	43.76	56.26	91.57	22.87	39.63	†29.57	†53.02	28.78	49.95	35.72	63.84
35	Yearly expenses lines 10, 20, 23 = 10½-hr. day		16.97	28.06	27.98	45.77	14.56	26.55	†18.78	†35.10	17.38	31.39	21.79	40.01
36	Cost of power, all exhaust steam used for heating	24 -hr. day.			†37.61	†61.25								
37	Cost of power, same as line 36 but short run	10½-hr. day.			†19.07	†30.68								
38	Cost of power, 50 per cent. exhaust steam for heating	24 -hr. day.			42.41	69.56								
39	Cost of power, same as line 38 but short run	10½-hr. day.			21.11	34.90								
	Total cost, lines 6 + 16 for entire plant		$51,000.00		$7,200.00		$61,500.00		$13,400.00		$56,500.00		$12,500.00	
	Water evaporated per lb. coal, at 212°		10 00		8.00									

motors at about two cents per kilowatt-hour the cost got up to $350 a month, but with a greater load, and running 24 hours a day all the year around. Changing back to gas engines running on natural gas at 30 cents per thousand the bills dropped to $73.10 for the period between September 13 and October 27; the November bill was $29.72, December $57.60, January $39.12, February $40.84 and March $58, an average of $46 per month.

L. G. Findlay, of the De La Vergne Machine Company, presented the comparison between steam and gas engines of 1000 and 200 horse-power, as shown in the table on page 459. Lines 36, 37, 38 and 39 of the table are computed on the basis of 80 per cent. of the value of the steam consumed by the engine being available for heating, but no standing charges are made against the heating plant. Concerning the possibility of heating with gas-engine exhaust, Mr. Findlay said: "If we heat the jacket discharge water with exhaust gases to about 180 degrees Fahrenheit, making a hot-water system, we can heat about 3000 cubic feet of space per brake horse-power up to 70 degrees. By rejecting the greater part of the jacket water and raising the rest to steam of, say, 5 pounds, we are able to make 2.48 pounds of steam per brake horse-power-hour. Beyond this we cannot go except with an uneconomical engine."

The steam men objected to the comparison of steam and gas engines on the rated horse-power basis, because of the much greater overload capacity of the steam engine as compared with the gas engine. The subject will be continued at the Cleveland meeting in November.

Some Electric Power Experience

In a paper of the above title read at the Washington convention of the National Electric Light Association, the author expressed the opinion that individual motor drive is not generally advisable unless it effects a power saving equal in value to 20 per cent. of the excess cost of installation over the cost for group driving. Of course, this does not apply to cases where the increased convenience, absence of power-transmitting equipment, or other special features are of great importance.

The author also advocated the use of roller bearings for line- and counter-shafts where group driving is used, and the division of line-shafts into relatively short lengths.

In a case of plant overhauling cited, changing from tight crossed belts to comparatively slack straight or open belts effected a total saving of three horse-power in a group of twenty machine tools. Substituting an electric motor for a gas engine driving automatic machines increased the output of the machines 10 per cent., by reason of the more uniform speed—the constant turning moment permitting a heavier cut on all the tools.

Boiler Explosion at Conn, Ont.

By J. H. Walters.

The accompanying illustration partly shows the havoc occasioned by a recent boiler explosion at Conn, Ont., eight miles from Mount Forest, which resulted in the death of two men. It was a single-riveted, lap-joint, return-tubular, iron boiler, 50 inches in diameter and 12 feet long, containing fifty-eight 3-inch tubes. The front sheet, with dome attached, was blown into some bushes 100 yards away; the rear sheet was blown rearward 130 yards from the setting, and the central sheet about 10 feet in front of the setting. The tubes were scattered in every direction and the heads were left bare.

The boiler was not under inspection, as many in the province are. After the explosion two inspectors visited the scene, but were unable to agree as to the status of the boiler before the accident. The plates, which were 5/16-inch, did not show any weak spots, however. The only source of water supply was through an injector. The boiler was equipped with a ball-and-lever safety-valve, and a few days before the explosion a new steam gage was put on.

THE PIECE MARKED "X" IS THE CENTER SHEET

The motor used by M. Santos Dumont in his recent successful attempt to fly with an aeroplane weighed slightly more than two pounds per horse-power.

To Prevent Passage of Cold Air Through Boiler Walls

In a paper read at a meeting of the Northwestern Electric Association, A. Bement spoke of the attention that the passage of cold air through boiler walls is receiving. He said that, even at the best, brick settings are very leaky and allow the entrance of much cold air. Steel jackets for the walls and reinforced concrete have been used as a remedy, and in some instances brick settings have been sealed by the application of a tight cement covering over which canvas has been pasted and then painted.

SECTION OF BOILER WHICH LANDED IN THE BUSHES

Elementary Electrical Engineering—XVIII

Effect of Load Variations upon the Speed of Shunt-wound, Series-wound and Compound-wound Direct-current Motors

BY CECIL P. POOLE

Any direct-current motor, no matter what its type of field winding, if supplied with current of constant potential at its terminals, will run at constant speed if its field strength and the load do not change. This may sound like an unnecessary statement, since it has been explained in previous articles that motor speed is determined by field strength, impressed e.m.f. and voltage "drop" in the armature circuit. The statement is made, however, for the purpose of emphasizing the relationship of the four factors: supply voltage, armature-circuit resistance, load and field strength, to the speed. The relationship could be stated more simply by saying that the speed of a given motor is directly proportional to the *net impressed e.m.f.* divided by the effective field strength. The net impressed e.m.f. is that part of the supply e.m.f. which must be exactly opposed by the counter e.m.f. of the armature. Thus, if the supply voltage is 250 volts, the load 50 amperes and the armature-circuit resistance 0.2 ohm, the net impressed e.m.f. will be 240 volts, because the armature drop is $0.2 \times 50 = 10$ volts. The "effective" field strength is the actual field flux set up by the field winding after overcoming the armature reaction, which always weakens the field slightly.

The Shunt-wound Motor

Applying the opening statement of this article to the case of a shunt-wound motor operated on a constant-potential circuit with an adjustable external resistance in series with the armature, it means that no matter at what point the external resistance may be set, so long as it remains at that point, giving unchanging voltage at the motor terminals, the speed will be constant unless the field strength or load be altered. Thus, if a 110-volt shunt-wound motor having an armature-circuit resistance of 0.171 ohm and a speed of 1125 revolutions per minute with a load of 38 amperes, be operated with an external resistance of 1.629 ohms in series with its armature circuit and a load of 30 amperes, the total armature-circuit resistance will be $1.629 + 0.171 = 1.8$ ohms, and the "drop" will be $1.8 \times 30 = 54$ volts. This leaves $110 - 54 = 56$ volts to be balanced by the counter e.m.f. Without the resistance, and with 38 amperes, the counter e.m.f. was:

$$110 - (38 \times 0.171) = 103\tfrac{1}{2} \text{ volts,}$$

and the speed 1125 revolutions per minute. With the resistance and the load of 30 amperes, the speed will be:

$$\frac{56}{103.5} = 1125 = 608.7$$

revolutions per minute.

Now if the external resistance be changed the speed will change oppositely and almost proportionally, the torque of the load being constant. Thus, with constant load torque, increasing the resistance to 2.029 ohms will make the total resistance 2.2 ohms; this will reduce the current momentarily and the armature will reduce its speed until the current of 30 amperes is regained. The speed at which this will occur will be that corresponding to a counter e.m.f. of

$$110 - (30 \times 2.2) = 44 \text{ volts,}$$

and this speed is

$$\frac{44}{103.5} \times 1125 = 478.26$$

revolutions per minute.

An adjustable resistance in series with the armature is used for obtaining different speeds in cases where the load is not likely to change much after the desired speed has been obtained. Where the load varies considerably and frequently, however, resistance regulation is unsatisfactory because of the unsteadiness in speed produced by the changes in load.

Thus, if the motor mentioned above were operating at 500 revolutions per minute with a load of 32 amperes and an external resistance of 1.829 ohms, and the load suddenly dropped to such an extent as to require only 18 amperes, the armature would immediately speed up to 804 revolutions per minute.

(In the foregoing examples the effect of armature reaction upon the field strength is ignored for the sake of simplicity; it would not alter the results seriously if taken into consideration.)

The speed of a well-designed shunt-wound motor operating directly on a constant-potential circuit will not vary seriously with changes in load. The armature resistance is so low that the variation of the net impressed e.m.f. due to varying armature "drop" is a small proportion of the no-load impressed e.m.f. Thus, the 5-horse-power 110-volt design used in several preceding examples embodied the following data:

	No Load.	Full Load.
Armature resistance,	0.16 ohm.	0.171 ohm.
Armature current...	2 amp.	38 amp.
Armature drop	0.32 volt.	6.5 volts.
Net imp. e.m.f.....	109.68 volts.	103.5 volts.
Rev. per min., calculated	1192	1125

The decrease in speed, therefore, from no load to full, as affected by armature resistance, was 67 revolutions per minute, or

$$\frac{67 \times 100}{1192} = 5.62 \text{ per cent.}$$

In practice, however, as previously intimated, the armature reaction of a motor reduces the field strength slightly as the load increases, thereby increasing the speed slightly beyond the point it would attain with an absolutely constant field. In the case just cited, the actual full-load speed was 1146 revolutions per minute instead of 1125, so that the decrease from no load to full load was actually only 46 revolutions per minute, or

$$\frac{46 \times 100}{1192} = 3.86 \text{ per cent}$$

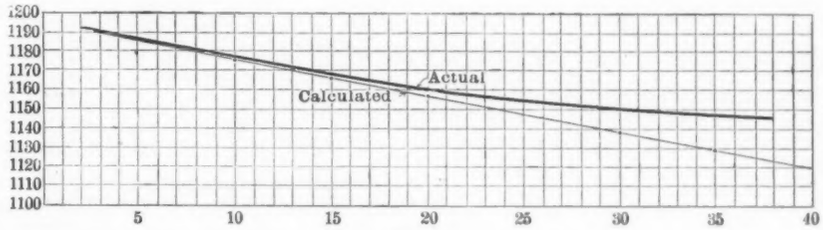


FIG. 51

The accompanying chart, Fig. 51, shows the calculated and the actual speed-load curves of this machine. It will be noticed that the calculated "curve" is a straight line, while the actual curve is not. This difference is due to the fact that the field magnet was worked at that part of the magnetization curve where the magnetic flux does not vary in proportion to variations in the exciting current. Therefore, the reaction of the armature current made less difference between no load and two-thirds load than between two-thirds and full load, giving the curved line.

Theoretically, it would seem possible to design a shunt-wound motor so that the increasing armature reaction due to increasing load would weaken the field just

enough to compensate for the decrease in net impressed e.m.f. due to increasing armature-circuit drop. Thus, suppose the armature resistance were such that the net impressed e.m.f. at full load were 91 per cent. of the net impressed e.m.f. at no load; it would only be necessary, apparently, to arrange so that the armature reaction at full load would weaken the field to 91 per cent. of its strength at no load, in order that the two effects might balance and produce identical full-load and no-load speeds. In the first place, however, a motor with such high armature reaction would doubtless spark violently at the commutator, and in the next place, it would be almost impossible to have the field magnetism decrease exactly in proportion to the increasing armature reaction throughout the range from no load to full load; consequently, the speed would not be strictly constant at all loads. Quite apart from and superior to these academic considerations, however, is the practical fact that rigidly constant speed is not necessary in many cases; where it is, it can be obtained by means of special motors of another type less difficult to produce.

Series-wound Motors

The speed of a series-wound motor increases very rapidly with decreasing load when operated on a constant-potential circuit, becoming so high at no load as to

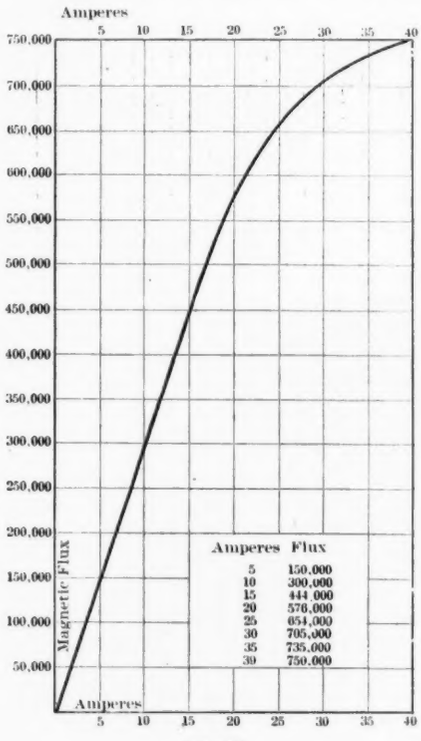


FIG. 52

be destructive to the armature. The reason for this is that the armature current passes also through the field winding, so that any decrease in armature current weakens the field and causes the speed to increase far beyond the rate it would attain with a constant field. For example, a 5-horse-power hoist motor design furnished the following data:

Full-load current.....39 amperes
Total voltage drop, full load.9.05 volts
Full-load counter e.m.f...100.95 volts
Full-load speed.....1140 r.p.m.

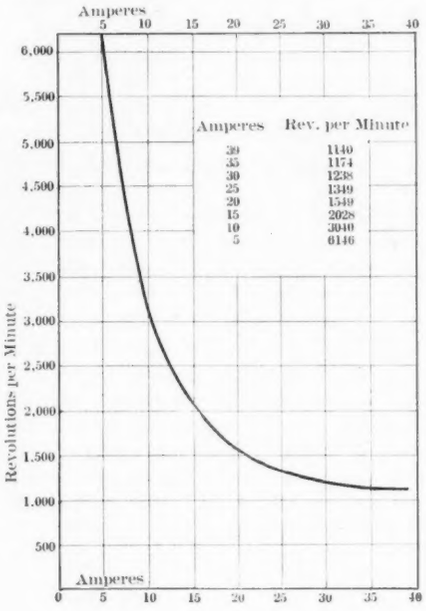


FIG. 53

The magnetization curve of the machine is reproduced in Fig. 52, from which it will be clear that the following values of magnetic flux were obtained with the values of working current stated:

Amperes	Magnetic flux
5	150,000
10	300,000
15	444,000
20	576,000
25	654,000
30	705,000
35	735,000
39	750,000

Now, since the speed of a motor is directly proportional to the net impressed e.m.f. and inversely proportional to the field strength, it is equal to the net e.m.f. divided by the field strength and multiplied by a constant which covers the fixed factors in the fundamental formula:

$$\frac{60 \times e \times p}{100{,}000{,}000 \times \Phi \times w \times m} = \text{r.p m}$$

In the case of the motor under consideration

$$\frac{8{,}470{,}000 \times e}{\Phi} = \text{r p m.}$$

Having these data it is easy to plot a curve showing the speed corresponding to each load, and Fig. 53 shows that curve, with the values to which it was drawn. The curve and table show that with a reduction of current from full load to about half-load value the speed rises from 1140 to 1550 revolutions per minute, and at 5 amperes the speed is 6146 revolutions per minute.

In order to steady the machine when operating under varying loads, it is customary to work the field magnet at high degrees of saturation. The more highly saturated it is at full load, the less will the speed increase at lesser loads, because a large variation in current produces a relatively moderate variation in magnetic flux.

It is impossible, however, to prevent very high speeds at very light loads unless some form of speed regulator be employed; and if the regulator requires manual operation, it is impracticable to use series-wound motors unless an attendant can be provided to control them as the load changes. Cases where series-wound motors are used to advantage are on hoisting machinery and railway cars, where an operator is constantly at hand and a controller is provided to regulate the speed—usually by means of an adjustable resistance in series with the motor.

Series-wound motors cannot be operated on constant-current circuits without automatic speed regulators, because the current in the field winding is constant and the field magnetization is therefore constant, so that if the magnetic torque

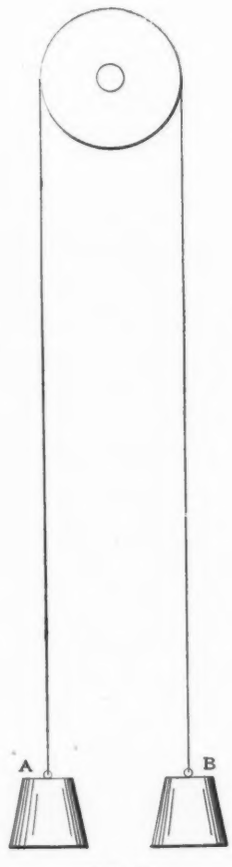


FIG. 54

exceeds the load torque, the armature runs away and destroys itself. Contrariwise, if the magnetic torque is equal to or less than the load torque, the machine will remain at standstill. There is no fixed impressed e.m.f. beyond which the

counter e.m.f. cannot go, as in a constant-potential circuit, because in maintaining the current constant, the e.m.f. at the motor terminals is increased continuously as its counter e.m.f. increases, so that there is nothing to restrain the armature, once the load is decreased below the point where it is just balanced by the torque produced by the constant armature and field current.

These operating characteristics may perhaps be made clearer by a simple mechanical analogy. Suppose a cord be hung over a pulley and a weight of 350 pounds be attached to each end of it, as in Fig. 54. Obviously the two weights will hang motionless. Now suppose that a pull of one pound is necessary to overcome the friction of the pulley journals and that a weight of two pounds be added to the end *A* of the cord. This will overcome the friction and give an excess pull of one pound; the result will be that the end *A* will be drawn downward all the way—if the weight *B* could pass through the pulley it would be drawn clear through. There is no point in the travel of the cord where the two ends will balance each other. Now suppose a series-wound motor with a 12-inch armature exerts a torque of 175 pound-feet when 10 amperes pass through it; this means a pull of 350 pounds at its armature periphery. Further suppose it to be put in a 10-ampere circuit, with a load which exerts a pull of 350 pounds at the armature periphery; obviously the two pulls exactly balance each other, so that the armature will not move. Now if the load torque be

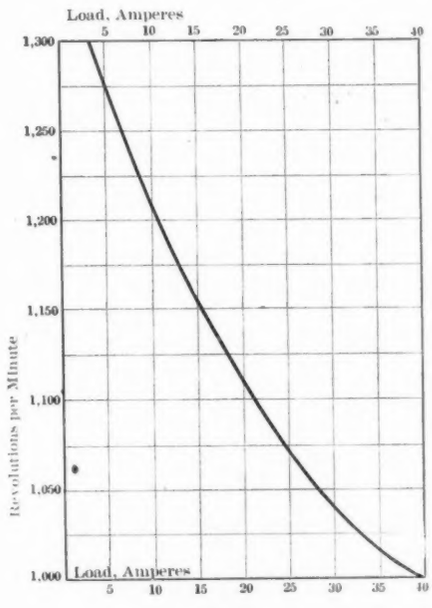


FIG. 55

reduced to 348 pounds and if one pound is required to overcome the armature friction, evidently there will be an excess pull of one pound, and that will cause the armature to run at a constantly increasing speed until "something happens."

The Compound-wound Motor

A compound-wound motor will not operate at constant speed with varying load, partly because the series field winding has the same effect as an external

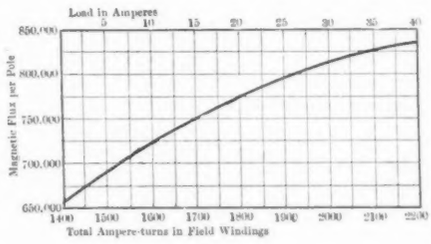


FIG. 56

resistance in series with the armature, but more especially because any increase in load increases the field strength and thereby reduces the speed. Fig. 55 illustrates the change of field strength with change of load. With no current in the armature, the series field winding is "dead" and the field magnet is magnetized by the shunt winding alone. This had 1400 ampere-turns per pole and produced a flux of 655,000 lines of force per pole in the machine used for this illustration. The series winding contained 20 turns per pole, so that each ampere of current through the armature increased the total field strength by 20 ampere-turns. The resulting increase in flux is shown by the curve. The speed of the machine at full load (40 amperes armature current) was 1000 revolutions per minute; the variation in speed caused by changes in load is indicated approximately by the curve in Fig. 56. Armature reaction is not taken into account here, the curve being calculated, not derived from actual test. It will be noticed that after the load passes 30 amperes, the decrease in speed with increasing load is less rapid; this is because the field magnet has reached such a degree of magnetic saturation that each additional ampere-turn produces less increase in flux than the preceding ampere-turn. See the magnetization curve in Fig. 55.

Of 49 German smelting works, 32 have gas engines at work and 9 have such engines ordered. The largest aggregate power at a single works amounts to 35,000 horse-power. Sixteen works possess over 10,000 horse-power, and 27 works have over 5000 horse-power in actual work. In March, 1906, sixteen collieries had 35 gas engines at work or being erected, of an aggregate horse-power of 30,300. Of these 24 engines of 15,600 brake horse-power are at work, all for the production of electricity. At present 29 firms in Germany build large gas engines, and of these 21 build double-acting four-cycle and 5 firms build two-cycle engines, while 3 firms build both systems.—*The Engineer* (London).

Three-wire Dynamos versus Motor Balances for Three-wire Circuits

In a paper on this subject read at the recent Electric Light Convention, Budd Frankenfield pointed out the following advantages possessed by the motor balancer over the three-wire generator:

It can be regulated, either manually or automatically, to maintain equal voltages on both sides of an unbalanced system; it will carry a neutral overload with good regulation; it permits the use of standard apparatus throughout the plant, while the three-wire machine is special and requires special equalizer arrangements for parallel operation; it does not seriously increase the cost of switchboard equipment and connections, as compared with the old two-dynamo arrangement; two-wire dynamos of over-all voltage may be added to a three-wire plant without any change in their construction; the danger of violent short-circuiting when "throwing in" a three-wire dynamo in parallel with another does not exist when motor balancers are used; the balancer may be located either in the generating station or at any point out on the distribution system.

Long Life of a Stack of Peculiar Design

Recently a correspondent inquired about a self-supporting steel stack of peculiar design erected at Syracuse, N. Y., in accordance with plans originated by Prof. John E. Sweet, which provided that the sections should each lap into the one below, instead of overlapping on the outside, as is customary. The idea advanced was that the stack would last longer built that way, as corrosive matter could not run down the inside walls and get into the joints. Professor Sweet was communicated with in regard to the query and replied as follows:

"The original stack built on the plan which I contended is right lasted fifteen years, while the life of the ordinary stack built of the same thickness of iron is about ten years. I have succeeded in convincing people in Syracuse that for all unlined stacks my plan is right. It ought not to have taken any demonstration to prove it; but it has. Besides the extra durability, if tapered (as is the case) and all the sections are made parallel, the stack looks better. For a nice top, the plan shown in the little fifty-cent book on 'Things That Are Usually Wrong' is not very expensive, and those who can afford a cornice on their buildings can afford a decent top to a stack."

Furnace Conditions and Smokeless Chimneys

Do You Make Smoke? If So, Here Are Means of Getting at the Conditions Which Cause It—Can You Find Your Own?

BY R. P. KING, M. E.

The following succinct statement of the relation of furnace conditions to smoke production has been compiled by R. P. King, of Brossmann & King, consulting engineers, of Indianapolis, Ind. Mr. King was for a long time chief smoke inspector of Indianapolis.

SMOKE.

Smoke may contain.....

Nitrogen	(N)	These to be avoided if possible
Carbonic-acid gas	(CO_2)	
Carbon monoxide	(CO)	
Sulphurous-acid gas	(SO_2)	
Superheated steam	(H_2O)	
Hydrogen	(H)	
Carbon	(C)	
Oxygen	(O)	

Cause of smoke
- Improper furnace conditions.
- Poor firing
- Both the above.

Direct losses to owner....

	Amount of waste:
Unconsumed carbon	14,600 B.t.u. per pound.
Unconsumed hydrogen	62,000 B.t.u. per pound.
Carbon monoxide	14,600–4,300 B.t.u. per lb.
Excess air	From 0 to 30% loss.
Insulation of tubes by soot	⅛ inch soot = 40% loss.

Indirect losses to the public
- Depreciation of property.
- Injury to health
- Painting buildings.
- Injury to merchandise.
- Washing and scrubbing.

Losses unknown, but enormous.

COAL.

Coal may contain, in varying quantities.....

		Heating value per pound.
Fixed carbon		14,600 B t.u.
Hydrogen		62,000 B.t u.
Volatile hydrocarbons:		
Marsh gas	(CH_4)	23,600 B.t.u.
Acetylene	(C_2H_2)	21,500 B.t.u.
Olefiant gas	(C_2H_4)	21,400 B.t.u.
Ethane	(C_2H_6)	22,200 B t.u.

Ash: Moisture. Clay. Slate. Earthy matter. Sulphur. — Make clinker. — Have no heating value.

Classification of Coals..... (Kent.)

	Per cent. Fixed Carbon.	*Per cent. Volatile.*	*Heating value per pound combustion*
Anthracite	97 to 92.5	3 to 7.5	14,600 to 14,800
Semi-anthracite	92.5 to 87.5	7.5 to 12.5	14,700 to 15,500
Semi-bituminous	87.5 to 75	12.5 to 25	15,500 to 16,000
Eastern "	75 to 60	25 to 40	14,800 to 15,500
Western "	65 to 50	35 to 50	13,500 to 14,800
Lignite	Under 50	Under 50	11,000 to 13,500

AIR.

General .....
- Oxygen..... 1 part } nearly.
- Nitrogen..... 4 parts }
- Weight, 0.081 lb. per cubic foot. } Atmos. press.
- Volume, about 13 cubic feet per lb. } 29.9" mercury.

COMBUSTION.

Air per pound coal .....
- 11 to 12 pounds, theoretical.
- 225 to 300 cubic feet, actual.

Too little air

Cause:
- Poor draft.
- Poor air supply.
- Poor grates.
- Clinker.
- Too small grate.
- Heavy firing.

Effect: Unconsumed hydrocarbons. Carbon monoxide. Low stack temperature. — Losses.

Excess air....

Cause:
- Too large grate.
- Poor draft.
- Poor firing.

Effect:
- High stack temperature.
- Low furnace temperature.
- Rapid movement of gases.

Ignition temperature
- Coal, coke and carbon..... 700° to 1000° F.
- Hydrocarbons ..... 1000° to 1300° F.

COMBUSTION—Continued.

Entering furnace

		In the ash-pit.
In the coal	Ash.	Ash.
	Sulphur.	Sulphur.
	Carbon.	Carbon.
	Oxygen.	
	Hydrogen.	
	Water.	
		In the chimney.
		Carbonic-acid gas.
		Carbon monoxide.
		Oxygen.
In the air: Oxygen. Nitrogen. Water.		Sulphurous acid. Nitrogen. Steam.

Flue gases....

Temperature may indicate:
- Excess air.
- Carbon monoxide.
- Insufficient heating surface.

Analysis will detect:
- Excess air.
- Carbon monoxide.
- Unconsumed hydrogen.

DRAFT.

Natural ..... Stacks. Chimneys. — Cheaper. Permanent.

Artificial .....

Forced	Steam jets; Blowers.	Mechanical
Induced	Exhausters. Steam jets.	Mechanical

Advantages of induced draft:
- Less space required.
- Independent of atmospheric conditions.
- Better control.
- Portable.
- Higher mechanical efficiency.
- Higher rate of combustion.
- Low first cost.

Poor draft....

Causes:
- Low stacks.
- Small stacks.
- Small passages.
- Poor baffling.
- Bad breeching.
- Leaky setting.

Effect:
- Low rate of combustion.
- Large grate area.
- Excess air.
- Unconsumed hydrocarbons.
- Carbon monoxide.
- High chimney temperature.

BOILER FURNACES.

General conditions for bituminous coal furnace.
- High temperature.
- 0.3" to 0.5" draft in furnace.
- Shaker grate.
- Fire-brick coking arch.
- Overload capacity.

Grates.....

Plain:
- Low first cost.
- Adapted to high-grade coal.

Shaker:
- Ease of cleaning fires.
- Adapted to coals high in ash.
- Fires always open.
- Breaks clinker.

Stokers: adapted to large plants

Advantages:
- Combustion of cheap coal.
- Saving in labor.
- Large capacity.
- Uniform furnace conditions.
- Smokelessness (generally).

Types.

Under-feed:
- Difficult to clean fires.
- Coal and air under automatic control
- Readily forced.
- Adapted to various settings.
- Readily banked.

Inclined grate—front to rear:
- Large capacity.
- Readily forced.
- Burn any coal.
- Adapted to large units.
- Should use steam jets.

Inclined grate—side to center.
- Adapted to small units.
- Air supply uniform.

Revolving grate:
- Low first cost.
- Readily forced.
- Adapted to small units.
- Hard to clean fires.

Traveling grates:
- Smokeless.
- Adapted to uniform loads.
- Cannot be rapidly forced.
- Easily repaired.
- Easily handled.

Steam Pumps versus Turbine Pumps

By Richard C. Williams

While the reciprocating steam pump will undoubtedly always retain a position of respect in the engineer's mind, it will as persistently stand as one of the largest elements of uncertainty in the operation of a power plant. The pistons and cylinders are sure to become worn, the packing must be renewed, repair and oil bills will always remain a source of expense and break-downs a possibility. These are governing factors whether the machine be used for boiler feeding, elevator service or any similar high-pressure service—in many instances duplicate outfits are installed to insure no possibility of a shut-down due to breakage.

It has been only a few years since the introduction of turbine pumps and since their adaptability for certain classes of service have been appreciated. At the time they were introduced in America the German and Swiss engineers had crudely perfected designs which gave promise of efficiency, competing with reciprocating pumps. At this time, however, we may be justly proud of the fact that pumps have been produced here which exceed in capacity, lift and efficiency anything which has been produced abroad.

The reader's attention should be brought to the fact that the very principle inherent in the design of the centrifugal pump permits construction to be made in cast iron or steel, lead, brass, acid-resisting alloys or materials suitable for contact with the liquid to be pumped. Acids are handled which it would be impossible, or certainly impracticable, to handle with a reciprocating pump.

No fair comparison between the cost and efficiency of the two types—reciprocating and centrifugal—can be made for *very* small capacities and high lifts, as the centrifugal pump is not practical for such cases. For very high lifts such as 1000 to 2000 feet, on the other hand, the centrifugal turbine pump would have decidedly the best of it. For mine drainage and heavy pressure work it is being used almost exclusively, owing to long maintained efficiency, small space occupied, absence of water hammer due to continuity of discharge, small oil and repair bills, etc. The efficiency of a reciprocating pump is never precisely twice the same, except by accident; wear of packing, grooving of cylinder linings, resulting slippage, etc., cause the operating efficiency of the steam pump to be an uncertain gamble. One thing is certain, however, and that is that as a rule the life of the reciprocating machine is short. This is just where the turbine pump depending on centrifugal action excels. There are no surfaces in actual contact, except at the bearings and stuffing-boxes. All the motion is rotary; there is not that element of jar which racks the reciprocating machine. The efficiency is well maintained, not only for months but for years, because there is no wear, no reason why it can drop. It has a larger capacity for its weight and space occupied, because it runs at a high speed.

There is one thing in particular against the centrifugal pump, however: it must be "primed" before it can be started; that is, the suction pipe and interior of the pump must be filled with water before it will operate. In most cases it is convenient to arrange to do this, and of course it causes no trouble at all if the pump is in continuous operation, or if means are provided for keeping the suction pipe filled with water when the pump is stopped.

While there is a constant expense for cylinder lining and valve renewals, packing, oil, etc., in the case of the reciprocating pump, there is no corresponding operating expense entailed by the centrifugal type. Another feature of the turbine pump is that the discharge may be closed while the machine is at full speed, with no bad results. This is due to the fact that the rotor or the impeller would merely "cavitate" in the water inside the pump casing, and prevent an excessive head being produced.

Perhaps as unexpected a use as any for turbine pumps is for boiler feeding. We will make a comparison on efficiences, weights and costs of several pumps, each capable of supplying feed-water (with the usual allowance for 100 per cent. overload) to 8000 horse-power of boilers operating at a gage pressure of 150 pounds per square inch. One thousand gallons of water per minute will be required.

If a reciprocating pump be used, this will need a 12x12-inch water end. For a simple duplex pump good practice would dictate a size about 16x12x12, from which one could expect a duty of 16,000,000. If a compound duplex pump, size 12 and 18x12x12, were used, a duty of 36,000,000 would be obtained.

On the other hand, consider a 6-inch four-stage turbine pump driven by a steam turbine. In the table are given approximate weights, duties and costs for two outfits, using two different makes of turbines, both 150 brake horse-power machines, running at a speed of 1900 revolutions per minute. The weights and duties are also given for the 6-inch four-stage turbine pump, as driven by either direct current or induction motor, which makes a very neat outfit if the electric power is at hand.

STEAM PUMP

Type of Pump	Weight.	Duty.	Approximate Cost.
Simple, 16x12x12 ..	7,500 lb.	16,000,000	$ 800
Compound, 12 and 18x12x12.....	11,000 lb.	36,000,000	1,000

FOUR-STAGE TURBINE PUMP

Driven by turbine "A," 40 lb. steam per hour.....	6,000 lb.	24,000,000	$ 2,500
Driven by turbine "B," 33 lb. steam per hour.....	8,200 lb.	29,000,000	2,450
Driven by direct-current motor..	10,800 lb.	38,000,000	1,850
Driven by induction motor	9,000 lb.	38,000,000	1,700

The duties given in the table for the turbine pump are figured as below (allowing 150 brake horse-power to drive the pump and 1193.5 B.t.u. per pound of steam used at 150 pounds pressure):

$$\frac{1000 \times 150 \times 8.33 \times 2.31 \times 60 \times 1{,}000{,}000}{40 \times 150 \times 1193.5} = 24{,}000{,}000$$

$$\frac{1000 \times 150 \times 8.33 \times 2.31 \times 60 \times 1{,}000{,}000}{33 \times 150 \times 1193.5} = 29{,}000{,}000$$

For the motor-driven pump the writer has considered the power derived from a generator having an efficiency of 92 per cent. direct-connected to a compound condensing Corliss engine using 20 pounds of steam per hour per brake horse-power. The motor on the pump is taken as having an efficiency of 85 per cent.

$$20 \times \frac{100}{85} \times \frac{100}{92} = 25.6$$

corresponding pounds of steam used at the motor.

$$\frac{1000 \times 150 \times 8.33 \times 2.31 \times 60 \times 1{,}000{,}000}{25.6 \times 150 \times 1193.5} = 38{,}000{,}000$$

Gas-engine Progress

A correspondent in *Engineering* states that a gas-engine station in course of construction at Madrid will have a capacity of 12,000 horse-power, in six units of 2000 horse-power each, and will be in full work by the end of the year. A plant of 48,000 horse-power is in course of erection at the Deutscher Kaiser Steel Works, and will consist of twenty-four engines of 2000 horse-power each. The United States Steel Corporation in America has placed large orders during the past year for gas engines of 3000 horse-power and upward, and the town of Scheveningen has been for many years past running exclusively by large gas engines. In conclusion, the writer says: "I have had occasion to pay rather frequent visits to Germany during the past few years, and every time I have found gas-engine houses being extended and larger units put down. All types of engines enjoy their share of patronage. The Nürnberg, Cockerill, Ehrhardt and Sehmer, Deutz, and Oechelhauser types may be found running in the same power houses, and the users of the large gas engines on the Continent seem to have passed through and to a great extent forgotten their early troubles."

The medal of the National Association of Cotton Manufacturers, for the year 1906, has been bestowed upon Charles Burleigh, in recognition of a paper presented by him, at the fall meeting of the association, upon the Curtis vertical steam turbine.

Practical Letters from Practical Men

Don't Bother About the Style, but Write Just What You Think, Know or Want to Know About Your Work, and Help Each Other

WE PAY FOR USEFUL IDEAS

Throttled Inertia Regulation

Mr. Crane's note on page 392 of the June number, regarding the use of a long pipe and of throttle valves for the purpose of reducing the sudden effect of heavy pressures on gages, brings to mind other and interesting uses of the throttling effect.

So long as a fluid has free communication, however small, through which it can act, it will ultimately establish an equilibrium of pressure on the two sides of the obstructive throttle. But if there is flow of the liquid or fluid, the degree of throttling cannot be so severe as when the pressure is purely static.

When two vessels are in communication and the pressure in one of them is rapidly varying in intensity, the mean intensity may be found by the method of throttling. A second vessel may be placed in communication with that in which the pressure variations are to be reduced to mean value. The communication between the two vessels is closed, or partially closed, by throttles. Then the pressure in the second vessel will vary with that in the first vessel, but the variation will be of smaller amplitude. The finger of the pressure gage on the second vessel will fluctuate with the fluctuations of the pressures in the first vessel, but the amplitude of the oscillations will be small, and by suitable means of throttling they may be reduced just as low as it is desirable they should be. The throttling should never be to so severe an amount as to render the oscillations of the finger imperceptible.

The principle has been made use of by Professor Ripper in his mean-pressure indicator. This is an ordinary pressure gage which can be placed in communication with the cylinder of an engine, or with other vessel of fluctuating pressure, and the passages are then gradually throttled until the needle scarcely moves. The needle will then point to the mean pressure. The throttling should be so arranged that the fluid can find as easy a passage one way as the other. The action of the instrument depends upon time; that is to say, it measures the relative duration of the pressures in point of time. Thus, if a pressure of 100 pounds is endured for a period of two units of time and a pressure of 70 pounds endured only for one unit, the mean pressure would be shown as 90 pounds; but if each pressure acted for an equal time, the mean pressure would be 85 pounds.

Since the movement of a piston does not coincide with time, its velocity being variable, there is a certain correction to be made in using the instrument in order that this may be allowed for. Such an instrument suggests itself, perhaps, for certain purposes and may be used for rapidly ascertaining the mean pressure in an engine. The reason for its action, that is, the principle on which such an instrument works, is that fluids can pass slowly through a small orifce and when communication is opened between the two vessels the fluid will flow faster toward the vessel in which the mean pressure is the less. Thus, gradually, the throttled vessel attains a mean pressure, and through the throttled passage the fluid then passes each way, as the external pressure fluctuates and allows of a slight fluctuation in the inner vessel; that is, the vessel beyond the throttle.

The argument is simple: The inner vessel tries to attain the pressure in the outer vessel, but time is required. The period of fluctuation is brief, and the fluid flow is so throttled that only a fraction of the flow necessary to equilibrium can pass each time. The result, namely, a steady mean pressure in the outer vessel, is the inevitable one. It is not possible to conceive of any other result. Similar effects in mechanics may be obtained to measure alternations of pressures or weights by means of levers acting through dash-pots. There must be inertia.

In steam engineering work there are two errors common in the ordinary atmospheric escape valve of a condensing plant. Steam can escape freely as soon as the valve is lifted from its seat. This is a mistake, because the fluctuations or pulsations due to the heating of the engine cause the valve to hammer on its seat. To prevent this undesirable condition, the valve should move toward its seat in a cylindrical approach-guard, so that when a free opening is affected the valve has moved, perhaps, two inches from its seat. The second error is the use of an air dash-pot on the lever which carries the valve. The idea of this dash-pot is to hold the valve against the above fluctuations, while still allowing it to move slowly to or from its seat.

Since air has no weight of any moment, and no appreciable inertia, it simply acts as a weightless spring behind the dash-pot plunger, and allows the valve to oscillate as it pleases. An air dash-pot is worse than useless in such a situation, for the valve becomes a pneumatic hammer at once and knocks itself and its seating into pieces.

The proper dash-pot for an atmospheric valve is an oil dash-pot, with the ends of the cylinder joined by a small pipe, with a throttle valve in its length and so regulated as to permit of a reasonably rapid movement of the valve to and from its seat, but possessed of so much fluid friction that the pull of the valve cannot force the oil round the passage fast enough to allow the valve to hammer; for once off its seat, it should remain off until the establishment of the vacuum pulls it down again.

W. H. Booth.

New York City.

"A Case of Demagnetized Field Magnet"

William S. Doughten's letter on the above subject in April Power, page 250, recalls a peculiar experience with a 20-kilowatt 110-volt generator in a cold-storage plant. It was a new machine, and had been run only a few days when it failed to generate one morning. As a result of tests, it was decided that the field was demagnetized.

In seeking a remedy, the Edison service was connected to the switchboard through one end of a double-pole double-throw switch, the center of which was connected to the bus-bars, and the other end to the generator. To excite the field the armature circuit was opened, "jumpers" were placed from the center of the switch to the generator end, and the switch on the Edison side was closed. This allowed the current to go through the shunt field, and the application of a screw-driver showed that the poles were magnetized.

In a minute or so the switch was opened and the machine, having been connected up again, generated all right. It worked well for two or three weeks and then stopped. The same remedy was applied and the machine ran along for several months, when it went out of business for the third time. The cause was found in a hitherto unsuspected place.

There was a high-speed belt directly above the generator, and static sparks

constantly passed between the belt and the eye-bolt in the top of the machine. The machine was moved away from the belt, and again excited by means of the Edison current, when it ran all right. This happened ten years ago, and I have never since heard of the machine giving trouble.

F. F. REDDING.

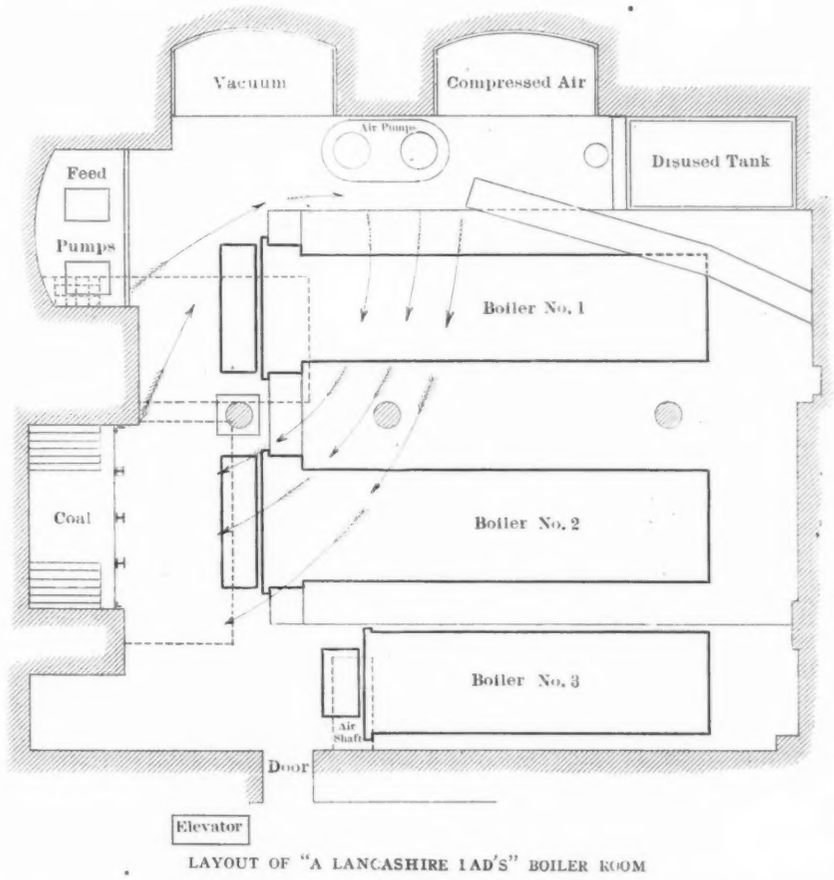
Brooklyn, N. Y.

The Ventilation of a Boiler Room

There are worse boiler rooms than the one I am firing in, yet this is bad enough. In cold weather the place is somewhat drafty and in warm weather it is a "sweating den." There are two floors below the street level and, of course, the boilers are at the bottom. The surface of the ground slopes a little, and the floor in front of the coal bunker is 26 feet below the street level. There are two Lancashire boilers, Nos. 1 and 2 in the sketch, and a Cornish boiler, No. 3. We formerly worked one of the larger boilers, with the Cornish ready to assist during a few hours in the afternoon. The owners have since lightened the load by taking electricity from the town and No. 3 is now out of commission. Nos. 1 and 2 work alternately, each a few weeks at a time, and carry the load comfortably in comparison to former times, although No. 1 does not work to my satisfaction yet.

The amount of head-room on top of the boilers is slight. There is about a foot between the boiler and the steam pipe and two or three inches between the steam pipe and the ceiling. Boilers and pipes are supposed to be covered, of course, but crawling over the composition does not keep it in good condition. The girders frequently remind us of their existence, also. The floor directly above covers the boiler room, except for the section shown by dotted lines.

Referring to the sketch, note the position of the air shaft near the door. Going up alongside the air shaft, but not around it, is a stairway, and on the landings are doors that open into the shaft. I have not seen these doors open lately, but they used to be left open in warm weather—to make it cool for the tenants, I suppose. (Part of the building is occupied for offices.) There are other holes that have no doors.



LAYOUT OF "A LANCASHIRE LAD'S" BOILER ROOM

Under these conditions I have found it interesting to note the motion of the air in the boiler room. The direction and rate of flow depend upon which boiler is working and the external atmospheric conditions. When No. 3 was working, for instance, the air for that boiler came down the elevator shaft near the door. The worst place, in warm weather especially, is in front of and around at the side of No. 1 boiler.

The air inlets comprise a few insignificant holes over one of the boiler feed-pumps, the grates over the coal bunker and the door. The boiler and air pump radiate heat toward each other. The heated air rises, more air rushes under. The hot air can only move in one direction and that is toward the boilers, where it gets more heat, then moves around toward the front again and makes for the air inlets—or are they outlets? Sometimes the circulation seemed to comprise alternate rushes of cool air in and hot air out; at other times the outer air entered at the side nearest No. 1, and dropped into the front of the coal bunker; the air entering over the feed-pump dropped in a vertical line till it struck the floor and made straight for the corner and around to the air pumps.

There is an electric fan behind No. 1 boiler to drive air out of the machine room, which is back of the boiler room; the blower tube from this fan extended right over the foremost pump. The hot air is driven over a hot main flue—there's a big bare patch there—thence over the side of a hot boiler and a hot side flue. On leaving the tube the air used to strike the wall and the vacuum tank, beyond the compressed-air tank, and was simply turned backward, being of no benefit either to us or to the boilers. If the language applied to that fan could have been put in the feed heaters it would have heated the water another ten degrees. The tube was shortened and a bottomless bag tied around its mouth. The weight of the bag deflects the air downward to the floor. The distance it extends forward is determined by the strength of the opposing current. The end of the current of air from the fan is turned upward and doubled back on itself. Near the end of the tube, but not quite in line with it, is a gas jet, and the bag will be fluttering from rear to front and the gas flame from front to rear.

Someone might ask: How does it affect the boiler as a steamer? Well, here we have two boilers side by side, of the same length, diameter, heating surface and grate area, using the same chimney and the same kind of coal, and the same work is demanded of each; but when it came to shifting from one boiler to another it was like shifting to a totally different plant. While No. 2 would show itself sensitive and respond readily to our efforts to regulate the pressure, No. 1 was very stupid. We were never, or very rarely, able to burn a fire off well enough to clean it properly. The machine stokers are coking stokers and the burnt stuff is dumped over the end of the bars. We had as much fire beyond the bars as we had on the bars; and once fire was dumped over, it would not burn nearly as fast. Underneath, the ends of the bars are sealed with small ash. Drawing the droppings from under the right-hand fire, the dust goes around the corner, very little going into the left-hand fire; drawing out from the left-hand fire, it all goes around the corner.

Perhaps I ought to mention that there is an air space of about two inches be-

tween the flue and the machine-room wall. The dotted wall rises to the ground floor. I have omitted the piping system so that the drawing might not be complicated. The pipes are a study by themselves.

A LANCASHIRE LAD.

Manchester, Eng.

Springs

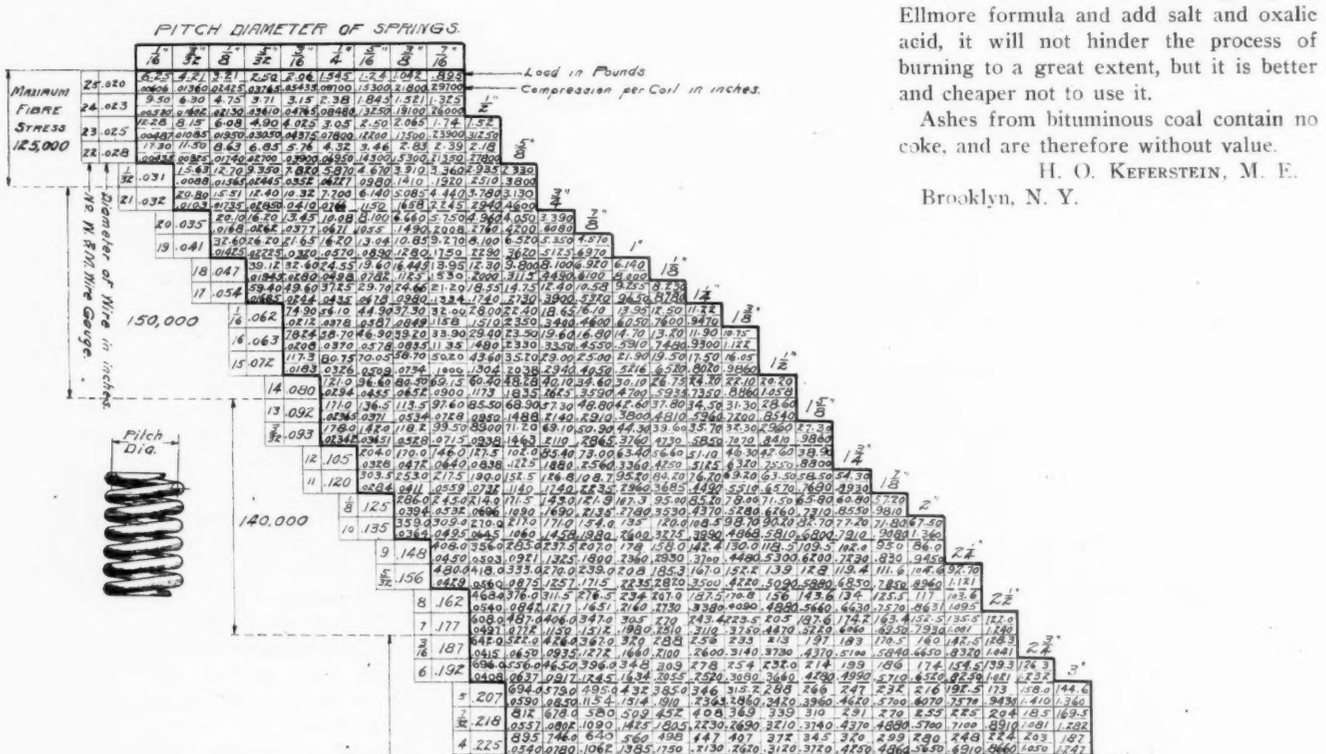
That portion of the article on "The Safety Valve" (on page 194 of the March number) dealing with compression springs suggested to me that the accompanying table might be of use or interest to POWER readers. This table has been adopted by designers in several shops, and is quite useful to those whose machines require springs for either tension or compression.

Of the table, however, I will raise the following criticism: The springs are wound on arbors the diameters of which are almost always even fractional parts or multiples of an inch. As the diameter of the wire is usually a decimal which cannot be reduced to a simple fraction of an inch, the pitch diameter is seldom the same as given in this table. A similar objection may be found to the table given in Kent's pocket-book, where the outside diameter is given in convenient dimensions.

As the author of the article on "The Safety Valve" says, "the pressure at which a spring will yield depends not only upon the shape and size of the material of which it is made, the diameter, number, and pitch of the coils, all of which are measurable and determinable, but upon the nature and condition of the material itself." From the latter part of this statement, we may see that the above objection is not a serious one, and for reference work these tables serve their purpose as well as any other.

CRESCENT.

Cincinnati, O.



STEEL HELICAL SPRINGS

Greatest allowable pressure in pounds and corresponding compression in inches per coil, based on: Maximum fiber stress, 80,000 to 150,000 per square inch; torsional modules of elasticity, 12,600,000.

"Burning Ashes"

Concerning the "Burning Ashes" article in the June number, I beg to say that I have often tried the experiment of burning a mixture of anthracite coal and ashes from anthracite, and have found that this mixture gives a perfect fuel. The reason is plain: Anthracite ashes contain a large quantity of coke, which is half-burned coal, and mixing this coke with coal results in completely burning the coke.

If one were to use the alleged John Ellmore formula and add salt and oxalic acid, it will not hinder the process of burning to a great extent, but it is better and cheaper not to use it.

Ashes from bituminous coal contain no coke, and are therefore without value.

H. O. KEFERSTEIN, M. E.

Brooklyn, N. Y.

Regulating an Old Throttling Governor

Upon taking charge of a 350-horse-power compound engine equipped with a fly-ball governor, I found the speed regulation to be very poor; and as it was run at 110 revolutions per minute any fluctuation in speed caused a lot of trouble throughout the connecting rope-drive system. To maintain the speed the compression screw had to be set in to the limit, but if the steam pressure dropped much below 100 pounds, the resistance of the spring was insufficient to counteract the effect. I used my inside calipers to ascertain the hight of the governor balls in the running position; also at the highest throw and when at rest. As I anticipated, the running position proved to be much too high for sensitive regulation, being almost four-fifths of the maximum. This condition was brought about by the valve-stem having been shortened as the spring resistance decreased with usage.

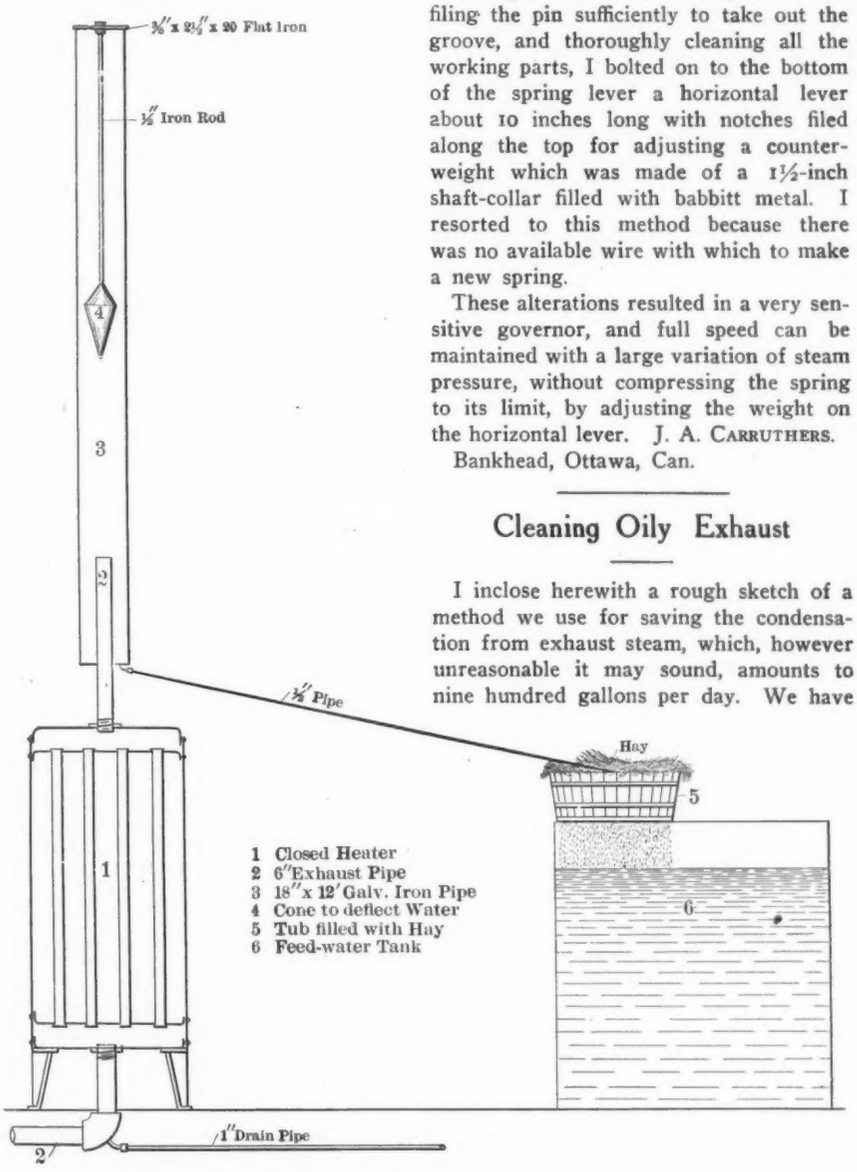
After lengthening the valve-stem so as to bring the running position of the balls down to between one-half and two-thirds of the vertical range, I examined the spring and the spring-pin to ascertain the cause of a jerky action which I had noted. This was due to a groove more than one-eighth of an inch deep on one side of the pin, worn by the top ring of the spring, which caused all spring and pin movement to take place with a decided jerk. After filing the pin sufficiently to take out the groove, and thoroughly cleaning all the working parts, I bolted on to the bottom of the spring lever a horizontal lever about 10 inches long with notches filed along the top for adjusting a counter-weight which was made of a 1½-inch shaft-collar filled with babbitt metal. I resorted to this method because there was no available wire with which to make a new spring.

These alterations resulted in a very sensitive governor, and full speed can be maintained with a large variation of steam pressure, without compressing the spring to its limit, by adjusting the weight on the horizontal lever. J. A. CARRUTHERS.

Bankhead, Ottawa, Can.

Cleaning Oily Exhaust

I inclose herewith a rough sketch of a method we use for saving the condensation from exhaust steam, which, however unreasonable it may sound, amounts to nine hundred gallons per day. We have no trouble in saving the water, but do not know how to separate the oil from the water.



ARRANGEMENT FOR CLEANING OILY EXHAUST

As the sketch shows, we have tried to get the oil out of the water by putting a tub filled with common prairie hay under the pipe from the exhaust separator. This does very little good, taking out only a small amount of the oil. I would be much obliged to anyone who will give me an idea as to the best way to get this oil out.

Morgan, Texas. W. F. BURROW.

Incorrect Indication of Water Level in Boilers

In a great many instances, due either to an erroneous or necessary method of connecting up the water column to the boiler, a false record of the true water level in the boiler will be shown. Such condition most generally occurs in connection with vertical boilers of such construction that the bottom water connection to the water column must be taken off down close to the fire-box, due to the peculiar arrangement of the tubes inside. This necessitates a vertical rise of connecting pipe of from say eight feet to twelve feet, entirely exterior to the boiler. It is by reason of this exposed rise of pipe that the damage results.

To prove that such is the state of affairs, let us present an illustration. Assume the connections between the water column and the boiler to be of 1-inch pipe and that the vertical distance from the lower connection to the water level in the gage glass is 12 feet. Now, it is evident that this water-leg, exposed as it is to a lower temperature and, not being affected by the circulation, will naturally be cooled down to nearly the temperature of the boiler-room, which we shall say is 80 degrees Fahrenheit.

Taking the boiler pressure at 125 pounds per square inch, its equivalent temperature will be 352.8 degrees Fahrenheit. With the volume of water as 1, at 39 degrees Fahrenheit, from the table we find the volume at 80 degrees Fahrenheit = 1.00325, and that at 352.8 degrees Fahrenheit = 1.1095. The volume of water in the vertical 1-inch connection will be $(0.71 \times 144) = 102.24$ cubic inches (0.71 square inch = inside area of 1-inch pipe); but this corresponds to

$$102.24 \times \frac{1.1095}{1.00325} = 113.07$$

cubic inches, the volume of the same weight of water inside of the boiler.

Hence the actual water level inside of the boiler would be

$$\frac{113.07 - 102.24}{0.71} = 15.25$$

inches above that indicated by the gage glass of the water column.

This is a point well worth keeping in mind, for, aside from the danger of damage due to incorrect recording of the water level, such knowledge may often prevent condemnation of boilers when seemingly they are not operating correctly, due altogether to fallacy in the water level carried.

Vertical boilers which require this long external rise of vertical pipe to the water column should be figured for this error and then by the addition of the result obtained to the level indicated in the glass, the correct level in the boilers may be had.

CALVIN B. ROSS.

Springfield, Ohio.

"Large Boilers"

I must thank Mr. Creen for his letter in the April number in reply to mine of last December (signed "Lancashire"). He gives me information of a kind I want. I know it is not unusual to compound an engine when having new boilers to work at a higher pressure, provided the existing engine is capable of standing the higher pressure. The engine referred to cannot stand to work at a higher pressure than 90 pounds, although the boiler is, I am told, able to work at 160 pounds.

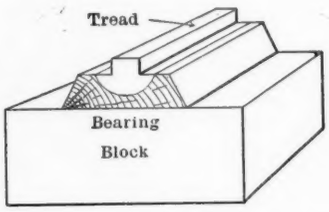
Considering that education has been compulsory in this country since 1870 or thereabout, an "engineer" unable to read or write may be a *rara avis,* but the men who can hardly do any more are not uncommon. Marine engineers are required tc pass board of trade examinations before taking responsible charge of the power plants of steamships, and some employers give these men the preference on plants ashore. Of the men reared on shore plants there are all sorts. It is not compulsory to show or prove competency. There has been agitation at times to bring this about, but a lot of employers seem to be afraid that it would diminish the supply, and that they would have to pay higher wages; while the men themselves seem afraid, because they would have to use their brains as well as their hands, so the agitations, thus far, have fallen flat.

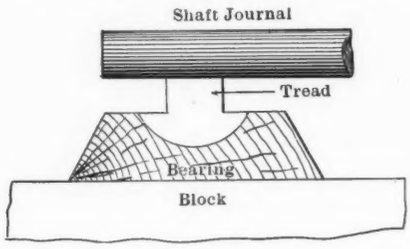
With regard to long Lancashire boilers, I am aware that this type has, like others, had to go through its experimental period. In a 30-foot boiler the fire door will be about 4 feet from the floor, and the fire grates about 6 feet long. When the grates get longer they begin to get difficult to manage, and as it has been found that there is little or nothing to be gained by anything in excess of 30 feet, with grates 6 feet, this length seems to be settled upon as full size for new boilers. The dimensions of the fire grates of the boiler I mentioned are given to me as 8 feet by 3 feet 6 inches, making 56 square feet. I got hold of a book about six years ago (I paid for it), entitled, "Steam Boilers," by R. Armstrong, C. E., which gives results of experiments in this direction. I quote from it: "The evaporating power of a boiler is always found to be, other things remaining the same, in proportion to the area of the fire grate; and to this may be added the evaporative economy of a boiler is always much increased by any increase of heating surface immediately over or very near the fire, the area of the fire grate itself remaining the same, or in some cases even diminished." "Certain it is, that 2 or 3 square feet of additional surface over the hottest part of the fire grate makes a considerable improvement in the power as well as the economy of the boiler, while as many square yards of surface added to the contrary end has scarcely any perceptible effect at all, provided that the proportions of the boiler in other respects remain the same. It has been found that when boilers of 20 feet long have been lengthened by 10 feet the addition has made scarcely any difference in the evaporating power, while the fire grate remained the same, and the saving of fuel, if any, has only been very trifling." "In one particular instance I recently met with in that county (Lancashire) a large boiler, constructed on the Cornish principle, 30 feet in length, was made 15 feet longer with very little or no improvement in either power or economy. Again, I have seen a boiler cut down from 104 feet in length to 50, without any sensible diminution in its evaporating power." The next paragraph states that the above instance occurred at an extensive paper works, near Manchester, and that several boilers 60 and 70 feet long, may be met with in the same neighborhood, and that another boiler 90 feet long worked some years in a cotton mill in Manchester.

I do not know when the book was originally written, but it seems to be an old-timer. This one is given as the eleventh edition, published in 1892. Perhaps the boilers Mr. Creen mentions were relics of the same period?

A Lancashire Lad.

Manchester, Eng.





BALANCING THE ROTOR OF A STEAM TURBINE

"Balancing the Rotor of a Steam Turbine"

I have expended some thought on the "Balancing the Rotor of a Steam Turbine" problem, presented by G. J. Walton in April Power, page 259, and have come to the conclusion that although there may be certain formulas, constants, etc., employed for determining various kinds of stress, none seems to be applicable to that particular case. It would be difficult to determine the area of surface in contact with the treads. It seems to me that an actual trial only would demonstrate just how wide the tread pieces should be. They should be made of a softer metal than that in the shaft which is to be balanced on them, so that if anything is to be bruised or marred, it will be the treads rather than the journals of the shaft. The sharp square corners of the treads should be rounded off, and in order to meet any inequalities which might exist, some such plan as suggested in the sketch herewith can be adopted, if all the surrounding conditions permit.

The base of the tread is semi-circular and, fitting in a groove of similar shape, permits the tread to find a true bearing, so to speak, and at the same time present a flat surface the whole width of the tread for the shaft to roll upon. Each tread would then adjust itself to the shaft, whether the shaft were perfectly level or not.

Under these conditions I do not think that marring of the journals would occur. Perhaps, by making assumptions and substituting "ifs" and "ands" in the calculation, a formula might be devised and applied that would give an approximation to the result sought for. Probably a practical trial or experiment or two would be the quicker way to find out what is required.

Charles J. Mason.

Scranton, Penn.

Why More Fuel to Sustain Lighter Load?

We are operating the Holly low-pressure steam-heating system in connection with our electric plant. The boiler capacity is 1400 horse-power, and the boilers are connected by U-bends to the main steam header. The day load is about 700 kilowatts, and the night load 1200 kilowatts. The exhaust from the engine goes direct to the steam-heating mains at a back pressure of 5 pounds. We find the exhaust sufficient to keep up the pressure of 5 pounds in mild weather, but in colder weather it is necessary to add live steam, through a reducing valve, from the main steam line.

Now our experience has been as follows: The 700-kilowatt connected load in the daytime in cold weather takes considerably more fuel and firing to keep up the pressure of 5 pounds, adding live steam, than it does during the night load of 1200 kilowatts, when live steam is not required to keep up the pressure of 5 pounds. We think the conditions should be just opposite as there is a condensation in the engines of from 10 to 15 per cent. I know of other companies operating under the same conditions which have like experiences. Can any Power reader explain the matter?

August Weis.

Johnstown, Penn.

A Few Observations on Packing Rings

Failures have resulted before now because a packing ring was poorly made, and it must be borne in mind that rings for horizontal engines should be different from those intended for vertical engines. Pistons in the latter are harder to keep

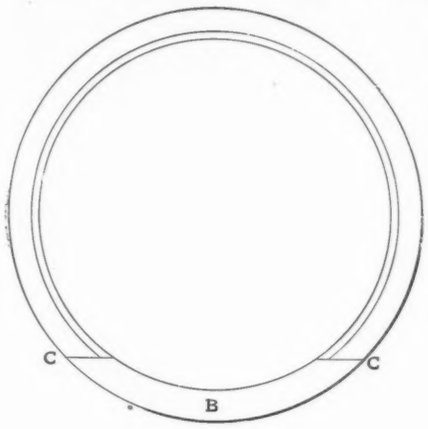


FIG. 1

tight and require a special type of ring for the best results. In my periods of investigation I have found very few really good rings in use, and often those which cost the most are most inferior.

First, consider the plain round ring shown in Fig. 5. The outer circumference *D* represents the bore of the cylinder. Note how this ring fits the bore? Now this is precisely the way 50 per cent. of them leave some shops; the workman

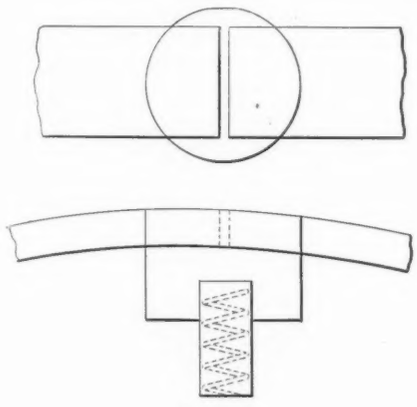


FIG. 2

simply turns a blank, cuts the ring off, puts it on the head and lets it go at that. This ring could be made to do much better work by re-chucking it on a face-plate, springing it in and re-turning. By so doing the ring would be true and fit the walls of the cylinder. Many engine-repair men make rings of this style also and cannot see any reason for using a dowel *E* to keep the ring joint at the bottom, which is right and proper. If this joint is allowed to work around in the groove in the piston head until it gets on top, there is nothing to prevent the steam from flowing through it.

Fig. 1 depicts the way Pof. John Sweet makes his piston head, which is well suited for a horizontal engine. After turning the groove in the piston head he has a ring turned, cuts out a section *B*, fills the groove and then cuts a like section out of the packing ring. The only chance for a leak to occur in the piston is by the ends of the rings at *C C*, as these will open as the rings wear; but this leakage will be very slight. However, should this head ride the stuffing-box and not the bottom of the cylinder, as intended, it will leak quite badly. Practice has shown that the ring in Fig. 6, properly made and with a good dowel, is superior. I have tested these both on a new and an old engine,

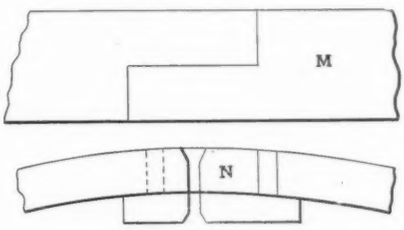


FIG. 3

with most excellent results. The elliptic ring allows for proper expansion and, combined with the dowel-pin arrangement alluded to, makes a highly satisfactory ring for use on a horizontal engine.

Figs. 3 and 4 illustrate what has been submitted to me as the best way to cut a packing ring. This joint looks good to those who cannot "see" into such a joint, especially when tightly closed, as in Fig. 3; but as soon as the ring commences to wear, the joint will resemble that in Fig. 4. A great many machinists do not seem to realize that steam simply goes in at *O* and out at *X*, as they do not dowel such a ring. When this joint gets to the top of the cylinder there will be a constant

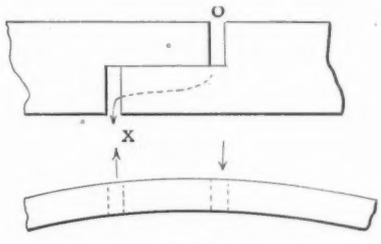


FIG. 4

blowing off. It takes a lot of time to cut this joint and it amounts to nothing when done. By making the same joint and using a brass shoe, as shown at *N*, Fig. 3, it will hold better and wear longer. The small parts on the rings become loose and many times cut the cylinder, anyway.

A joint like that in Fig. 2 is a good one if doweled to keep the ring in place. The ends of this ring are protected by a shield held in place by a bronze plug, in which is a small coil spring to hold the joint out against the cylinder wall. This is the most satisfactory joint that I have been able to find. It has been used by certain Corliss-engine builders for several years, and it shows up well in practice.

In a vertical engine I prefer the ring shown in Fig. 6 in conjunction with the joint shown in Fig. 2; if well made, it

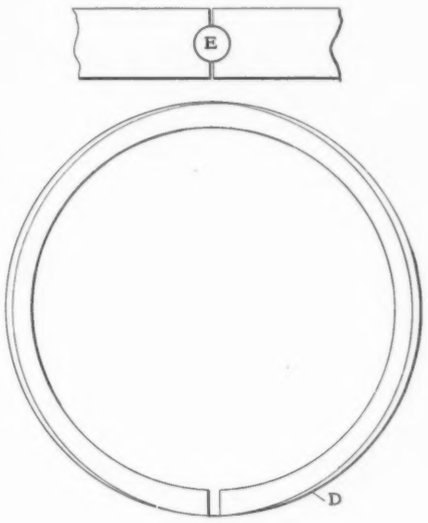


FIG. 5

will be an almost perfect ring. Many use the sectional ring with this joint in large engines. For some places it may be better, but for medium-sized engines I have failed to find where the sectional rings were better. I have found many of them extending through the piston head, coming to pieces and tearing holes in the heads.

It is a great folly to make a packing

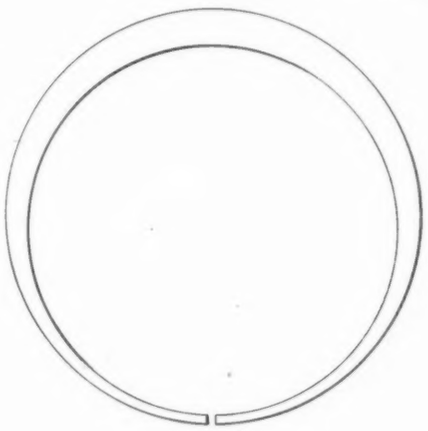


FIG. 6

ring too wide. I remember one instance of a set of pump rings about three inches wide; the pump would not work, so the rings were put in the lathe, re-turned with the spring in them and put back. The pump worked all right then. The trouble was that the rings fitted like that in Fig. 5. I have taken wide rings out of a steam pump, put in rings sometimes one-quarter the width and got better results. It took less steam from the throttle to run the pump on the same boiler pressure.

Atlanta, Ga. C. R. McGAHEY.

Cone-pulley Belts

If the belt on two cone pulleys be run crossed, as from a counter shaft to a lathe or other machine requiring changes of speed, there is no change in its length as it is shifted from one pair of pulleys in the series to another; if, however, the belt be run open, there is a change in the length for each pair. As one cone is the counterpart of the other, and the steps in each series equal, it necessarily follows that the sums of the radii of each pair of pulleys are equal, and it is on this theory that cone pulleys are built.

The relation of the lengths may be shown in the following manner:

In Figs. 1 and 2

Let x = the radius of the smaller pulley.

y = the radius of the larger pulley.

θ = angle BCE or $AC'F$;

And L = length of belt.

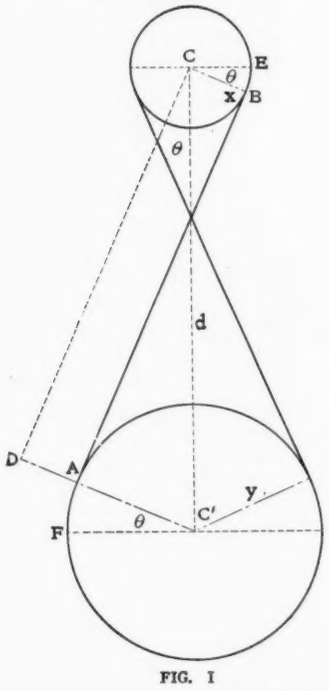


FIG. 1

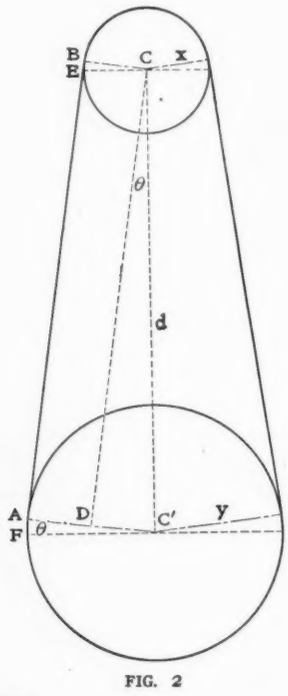


FIG. 2

CONE BELT PULLEYS

Then in Fig. 1

$$L = \pi x + \pi y + 2\theta x + 2\theta y + 2AB$$
$$= \pi(x+y) + 2\theta(x+y) + 2AB$$

But it is clear that if x be increased by a given quantity, and y diminished by the same quantity, the length of AB will not be changed by reason that the alteration will only cause AB to move through a small space, parallel to itself between two parallel lines, BC and AC, θ is constant, and $x + y$ is constant by hypothesis.

In Fig. 2, however, where the belt is run open, we find:

$$L = \pi x + \pi y + 2\theta y - 2\theta x + 2AB$$
$$= \pi(x+y) + 2\theta(y-x) + 2AB,$$

which varies as $y - x$ varies. Here AB changes, since it involves $y - x$.

We might proceed further and find a more practical formula for the length.

In Fig. 1

$$AB = \sqrt{d^2 - (x+y)^2},$$

thus making

$$L = \pi(x+y) + 2\theta(x+y) + 2\sqrt{d^2 - (x+y)^2},$$

letting

$$\theta = sin.\ \theta = \frac{x+y}{d}, \text{ and } x + y = c$$

$$L = \pi c + 2\frac{c^2}{d} + 2\sqrt{d^2 - c^2}.$$

In Fig. 2

$$AB = \sqrt{d^2 - (y-x)^2},$$

thus

$$L = \pi(x+y) + 2\theta(y-x) + 2\sqrt{d^2 - (y-x)^2}.$$

Letting

$$\theta = sin.\ \theta = \frac{y-x}{d}, \text{ and } y - x = z,$$

$$L = \pi c + \frac{2z^2}{d} + 2\sqrt{d^2 - z^2}.$$

For example, if the diameters of the steps of the pulleys be 4, 6, 8, 10, 12 inches, and d equal 120 inches; for 6 and 10 inches,

$$L = 3.1416 \times 16 + \frac{2 \times 4 \times 4}{120} + 2\sqrt{14{,}400 - 16}$$
$$= 50.065 + 0.266 + 239.86 = 290.191.$$

For 4 and 12 inches

$$L = 50.065 + 1.066 + 239.58 = 290\ 711.$$

For a crossed belt on the same pulleys, the length

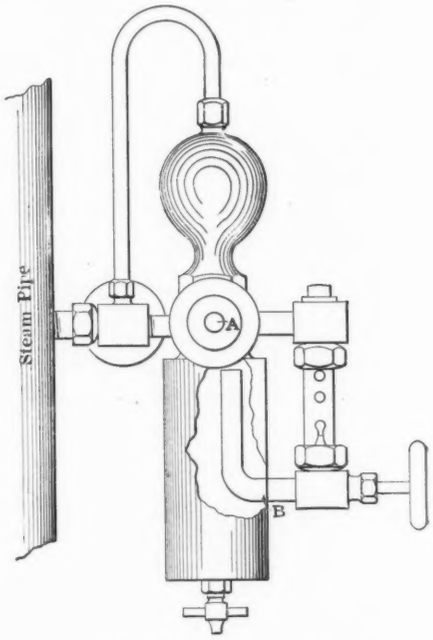
$$L = 3.1416 \times 16 + \frac{2 \times 8 \times 8}{120} + 2\sqrt{14{,}400 - 256}$$
$$= 50.065 + 4.266 + 237.84 = 292.171.$$

Kansas City, Mo. G. R.

Why Would Not the Lubricator Work?

A year ago I had charge of a forty-horse-power slide-valve engine running at 145 revolutions per minute, 85 pounds boiler pressure. The engine was equipped with a single-connection lubricator of one-half pint capacity, which gave considerable trouble. Its action was as follows: After filling I would allow it to stand for 15 or 20 minutes to give the condenser time to fill. I would then start the feed, and it would work well for about five minutes. The feed would gradually slow down and finally stop; then if I would loosen the gland on the valve-stem A and allow about twelve drops of water to come out, it would start again and continue for about three minutes, when it would stop as before.

After repeating the above operation five or six times it would refuse to work entirely, and oil and water mixed would flow out of the gland A when I loosened it. If I would empty the lubricator and refill it the performance was repeated. I took it apart and found everything O. K., as far as I could see, except that the joint at B was loose. I took the lubricator off the engine and put it onto a pump, where it worked finely. Once upon examining it I found the condenser full of oil. What was wrong?



SINGLE-CONNECTION LUBRICATOR

I am a young engineer of slight experience, and should be exceedingly grateful for suggestions from POWER readers. In truth, I pin considerable faith to the statements of your correspondents, and am a firm believer in this department of the paper.

St. Paul, Neb. ARTHUR R. MUTTON.

"The Steam Plant of the Wood Worsted Mill"

I was much interested in the article in February POWER on the Wood Worsted Mill, and in the subsequent comments. I have been trying to arrive at definite data in connection with the stoking of these boilers, and it appears that Mr. Diman is getting very good results from his hand firing, as regards the duty per man. The 6x6.5-foot grate = 39 square feet, and the horse-power per boiler = 200. At a coal consumption of 15 pounds per square foot of grate, there would be burned

$$\frac{39 \times 15}{200} = 2.925$$

pounds of coal per hour per horse-power. Mr. Diman says they fire in excess of this, the regular rate being 20 pounds per square foot, which is

$$\frac{39 \times 20 \times 19}{8} = 1850$$

pounds of coal per man per hour, and as the ash man's work consists in handling the refuse of four men, this will be on a 10 per cent. basis:

$$\frac{1850 \times 4}{10} = 740$$

pounds per hour. On the March test the men would handle something like a ton of coal per man per hour. Say the increase of coal per horse-power due to overload equals 5 per cent., the coal per horse-power equals $2.925 \times 1.05 = 3.07$ pounds, and the power of each boiler:

$$\frac{5800}{19} = 305 \text{ horse-power.}$$

The coal per man equals:

$$\frac{5800 \times 3.07}{8} = 2225$$

pounds per hour; and the ash man handles 880 pounds of refuse per hour.

The "Armstrong" system of handling ashes mentioned by Mr. Lane, namely, one man per 1000 horse-power, seems rather light, in this case one man for about three boilers, and on the test he would only handle about

$$\frac{5800 \times 3.07}{10 \times 5.8} = 307$$

pounds per hour. One would prefer this job to stoking and firing 1850 pounds per hour on a normal day's run, and a man to do the latter, and at the same time keep his fires in trim and mind his water glass, has to keep going at pretty nearly top speed all day. I am afraid we should not get many men to do that here. We consider a man to be doing a good day's work when he fires about 1500 to 1600 pounds per hour, and in addition each man watches his own water, fan, pump, etc. The coal may vary according to load; it may reach 40 pounds per foot.

We have no water tenders and never have used them; if a man is not intelligent enough to watch that point he is not fit to fire a boiler. Instead of water tenders we adopt a plan which answers very well; that is, we put one man (stoker) on as a leading hand on a battery and pay him about 20 cents a day more than the others, and he keeps his eye on the boilers, watches the steam, water, etc., and also gives the firing signals, if necessary.

In regard to mechanical stokers, one hears many tales of their success, but there is another side which we hear little about, which no doubt Mr. Diman has considered. I mean their liability to go wrong at critical times when they can be illy spared, and these repairs and losses would consume quite a little of the $3000 accredited to Mr. Diman's hand-fired plant. I could give several instances of well-known stokers eating their heads off in repairs, until several people have taken them out entirely. In a large electricity generating station a chain grate collapsed under a peak load, when every boiler in the place was wanted. Another firm has installed a special chain grate which has cost an immense sum in broken links, stoppages, etc. There is nothing more annoying than to be expecting to be told that "the grate is stuck again," and to have to decide whether to run the boiler on a standing grate, or stop the boiler and force the others to the last ounce at times. In either case you are in a hole. If you fire the grate standing, and especially with tarry coals, the air spaces are gummed up and the air won't pass, and when the week-end comes you find the price of a link is nothing at all compared with the extra wages for the men who have to get out the clinker and free the grate. With hand firing nothing very terrible can happen in this manner.

There are marvelous claims made for the increased efficiency with automatic stokers which I have failed to find justified in practice. If a boiler gives from 70 to 80 per cent. efficiency, I cannot see that there is much room to better it. In the matter of ashes alone, I have repeatedly got less refuse from a hand-fired boiler than from an automatically fired one, and I give herewith some gas analyses, together with results from hand-fired Scotch-marine boiler tests in our works:

GAS ANALYSES—AVERAGES OF 10 TESTS

Date	*Draft*	*CO_2*	*O*	*CO*
May, 1907	2½ inches	14.0	3.17	0
May, 1907	2½ inches	12.3	2.3	0

BOILER TESTS (45 SQUARE-FOOT GRATE)

Draft.	Gallons per foot.	Refuse, per ct.
1¾ inches.	25	4.56
2½ inches.	35	3.25

Water per lb. of coal from and at 212 deg.	Escaping Gases.	Water per hour, actual.
11.87	435	10,950 lb.
11.76	432	15,333 lb.

Tests from a chain grate taken under similar conditions show from 8 per cent. to 9 per cent. refuse.

I think the above are rather good and are a fair average. Mr. Diman's analysis does not appear very satisfactory, the CO_2 being low and the O being high; as the boilers were working on an overload, that would probably explain the presence of oxygen in such large quantities, and that brings me to a point I would like to see thrashed out, that is, whether it is advisable to have the draft fixed automatically for each boiler in such a way that it cannot be altered. It strikes me that it would be an advantage to have some means of shutting off the draft from any boiler independently and easily.

The samples in Mr. Diman's case seem to show an excess of air, the best sample being D, with 8.4 per cent. CO_2 and 10.9 per cent. oxygen, and this was taken with only one fan on, so possibly the air supply would be somewhat smaller than in the others. Samples B and E are high in oxygen and low in CO_2. As E was taken just after grates were shaken, the probability is that the fires being in good shape and comparatively open, the air had an easy passage, and it might have been an advantage to restrict the air for the time being.

I have had no experience with this class of boiler, but I have had a great deal of experience with the Scotch marine, and find that cold air is responsible for more repairs than one would imagine at first sight; this fact has led to putting in the base of the stack of each boiler dampers that can be closed easily when the fires are cleared, without shutting down the fan, and if I found one of the men clearing fires with the draft on I would "sack" him at once. Also, he regulates his draft according to the load, but I suppose in this respect the cases are different, as Mr. Diman's load appears to be pretty constant, while ours fluctuates considerably.

As far as I can see, the tubes in the boilers in the Wood mill are as likely to be affected by cold air as are those of a marine boiler, to say nothing of the reduced efficiency due to an excess of cold air. Of course, in the marine type one flue has to be cleaned at a time, and with one flue full of fire and one empty, the strains set up by cold air going through the empty flue are very severe, and would not be so severe in tubular boilers.

I notice Mr. Diman uses induced draft, with a fan for each battery. One thing against making the fans of such size is the awkwardness of finding one of them broken down when hard pushed, and several boilers being wanted at one time. In this respect smaller units are an advantage, as one can be laid off for repairs without stopping the plant at all. The stack is a large one, compared with ours, it being 78.5 square feet in cross-sectional area. We usually stick to the old proportion of one-sixth of the grate area, instead of 0.106. In this case, however,

we work a much higher draft and friction counts somewhat. With 20 boilers a smaller stack may be used, owing to the variation of the fires; they will not be all on and doing their worst together.

The system of making provision in some of the joints for stop-plates is very convenient, and if the joints do not have to be broken too often, they certainly save in first cost.

COSMOS.

England.

Testing Motors for Grounds

Some correspondents hold, regarding the best method of testing motors for grounds, that the frame of the machine to be tested should be connected to a ground, preferably a water pipe. This is not necessary. It must be borne in mind that a motor which is set on a wood floor may have a "dead ground," and yet the ground detector on the switchboard may not show it. There are three points at which grounds are likely to occur: in the brush-holder yoke, the armature or the field-magnet coils.

Suppose the motor is grounded, not to earth but in one of the parts named, and it is desired to ascertain whether such is the case. All that is necessary, if it is a ground of good conductivity, is to take a lamp with a short lamp cord attached, touch the armature leads with one end of the cord and the motor frame with the other end. Of course, one wire should be kept on the frame and the contact made with both armature leads alternately. If the potential of the grounded current equals 40 volts or more the lamp will light. If, however, the ground is of less than 40 volts potential, a voltmeter or a magneto may be used to make the test. The lamp test can be applied while the motor is running.

If it is desired to learn at what point the ground has occurred, take off the brushes and armature lead wires, connect one wire of a magneto to the shaft and touch the commutator bars with the other. If the magneto does not ring the armature is clear and it will be necessary to look elsewhere for the ground. To test the brush-holder yoke, connect one magneto wire to the yoke and with the other touch each brush-holder in turn. The field coils should be tested separately, first disconnecting the wires which join them in series. Connect one wire of the magneto to the field-coil terminal and form a contact with the field-magnet frame with the other.

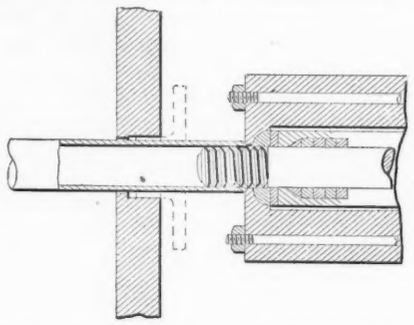
I have never found it necessary to set the brushes of a dynamo at the neutral point, when the machine is started, if it is a well-designed machine.

JOSHUA L. BICHELL.

Baltimore, Md.

Fitting the High-pressure Cylinder with a Special Metallic Packing

In regard to William Kavanagh's method of placing metallic packing, as described on page 33 of January POWER,



HOW SPECIAL METALLIC PACKING WAS FITTED TO CYLINDER

it seems to me that if the hole through the stuffing-box in the partition was large enough to allow the washer to pass through, a sleeve of sheet iron or one or more short pieces of common pipe could have been slipped over the rod and extended into the crosshead compartment. By simply backing up the crosshead against this sleeve the spring could have been compressed without substituting a wooden rod, and thus not only avoid the difficulty of inserting the rod after the packing rings were in place, but also avoid the chances of scratching the metal rings.

The accompanying sketch gives my idea, but of course there may have been obstructions, not set forth in the article, to prevent such a proceeding.

R. CEDERBLOM.

Chicago, Ill.

Peculiar Accident to Automatic Damper Regulator

The usual method when this plant is shut down for the night is to leave the three fires "spread" with the dampers closed, to comply with the insurance rules. Sixty pounds of steam pressure is maintained during the night to operate the fire pump, if need be. There is an automatic damper regulator operated both by steam and water pressure.

The night engineer recently reported that about 4 o'clock in the morning he found the dampers open and the fires completely burned out, with only 20 pounds of steam showing on the gages, due to cool air passing through the tubes. The burning out of the fires was due to the street main bursting during the night, thereby reducing the pressure on the damper regulator, and thus allowing the dampers to open. Before the blowing-off point was reached, however, the fires had burned out. The three furnaces had to be cleaned and new fires started up with wood. A hook was put on the regulator chain, which is detached every night, to avoid a repetition of the accident.

JAMES G. SHERIDAN.

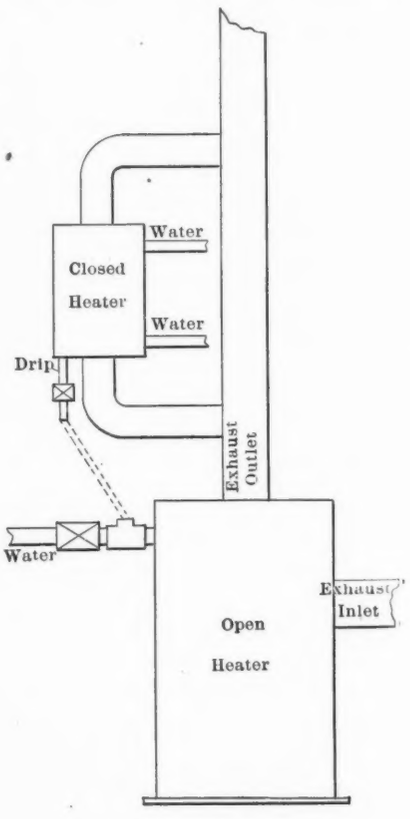
Brooklyn, N. Y.

Heater Drip Connection

"Say, Boss, what's the matter with connecting this drip-pipe with the big heater and stop all this mess?"

My pipe man approached me in this way about the drip-pipe of a small feed-water heater which had recently been installed for heating water for general washing purposes through the factory. It was heated by exhaust steam that had passed through an open heater of the type used where the exhaust is afterward employed to heat the building, and connected as shown in the sketch. The dotted lines show where the pipe man wished to make the new connection.

I told him that it would not work, but he was not satisfied; so to prove to him



HEATER DRIP CONNECTION

that it would not, I told him to go ahead with the connection, which he did one afternoon. By eight o'clock next morning every department "kicked" for hot water, which he could not give them until the connection was broken and the heater thoroughly drained. A pocket formed in the lower exhaust steam connection to the closed heater, and this helped to clog things up.

WM. T. DOUGHTEN.

Philadelphia, Penn.

The Value of Indicator Diagrams

Steam-engine indicator diagrams furnish an interesting study and to the intelligent student they are the keys that unlock the doors to a mysterious pound, or loss of economy. Many firms do not furnish indicators for their engines, because they do not realize the benefit to be derived from their use. An instance comes to mind, however, of an engineer who purchased one at his own expense, with gratifying results, both to employer and employee. Less coal was burned and in a short time the engineer's wages were increased 50 cents a day—pretty good interest on the money invested in the indicator. Not long after he was made chief engineer in a street-railway power plant, a situation he certainly would not have obtained if he had not been familiar with the indicator.

Several years ago, while I was pretty green at the business, I received a practical lesson on the use of the indicator that I am not likely to forget. I took charge of a plant consisting of a 7x10 Russell engine, running at 280 revolutions per minute, and a 30-horse-power return-tubular boiler. It was a wholesale grain store, where grain was elevated from the cars to the bins, and corn was cracked or ground into meal. Between six and eight hundred weight of meal was turned out per hour; certainly not enough to pay for the coal burned, to say nothing of the wages of an engineer and a miller. The engine would slow down if corn was fed into the mill very fast. As the belts did not slip, I thought the trouble must be in the engine. I tried to set the valve, but did not have experience enough to get it right; then I made up my mind that an indicator was needed. I suggested this to one of the members of the firm, but he claimed that the engine was all right and the trouble was with the mill.

Speeding up the engine from 280 to 300 revolutions helped matters slightly. A machinist recommended a change in certain pulleys, substituting pulleys of larger diameter, the speed to remain the same. This was done, but no output gain was perceptible. The only person who got any benefit was the machinist who sold the pulleys. Later on a belt manufacturer's agent advised placing a 6-inch double belt in place of a 4-inch one. This was tried, but with no improvement.

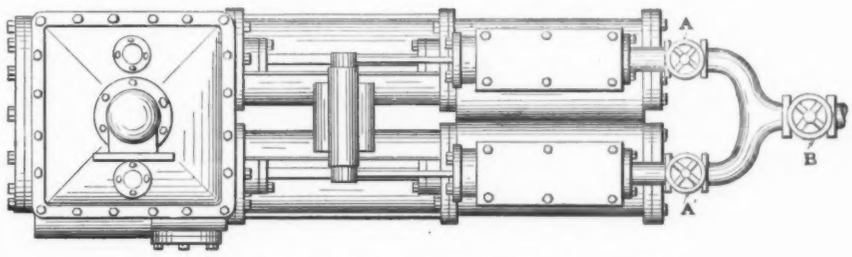
Things went on this way for several months, when one of the firm came into the engine room and said he would soon be looking for a job if there was not a change. Again I suggested that he have the engine indicated; he said there was no use doing it, as she was running just as well as ever. Well, I went to his partner and asked him to allow me to bring in a good practical engineer, a man with nothing to sell, to look over things and see if he could suggest any improvements that would not be too costly. I was given permission to do so, and that night I got a first-class practical man to look the place over. He said he saw no way of improving the boiler, belts, shafting or the mill. He recommended that an indicator be applied to the engine, and if the valve was not set correctly, that it be properly adjusted. They consented. A friend came and took some cards, which showed that the engine was doing nearly all its work at one end. A slight change equalized the load, and from then on we turned out from 25 to 30 hundred weight of meal per hour. The record was 32 hundred.

E. E. Brigham.

Springfield, Mass.

Effect of One or Two Throttles on a Duplex Steam Pump

What would be the effect on the steam efficiency of having a separate throttle for each cylinder of a duplex steam pump, as at *A A'* in the accompanying engraving, instead of a single throttle as at *B*, as is customary in present practice; the steam pressure to be 100 pounds, water to be pumped 100 feet high; size of cylinders, steam 12 inches, water 8 inches, stroke, 10 inches.



WOULD ONE OR TWO THROTTLE VALVES BE BETTER?

Frank J. Wood.

Brooklyn, N. Y.

The Trouble with the Crank-end Diagram

A. P. Aldrich asks in June Power, page 395, "How would you correct the crank-end diagram?" The inquiry is accompanied by two interesting diagrams from a 14x36 Corliss engine, running at 92 revolutions per minute. From the appearance of the diagrams I am of the opinion that the engine has but one eccentric, and this has probably slipped back from its correct position, as the events as recorded are late.

The head-end diagram shows late cut-off and late release, while the crank-end diagram shows late admission. If Mr. Aldrich will move the eccentric on the shaft just a little in the direction the engine runs, and then take a card, being sure not to forget the atmospheric line, I think he will notice a decided improvement. Then when convenient repeat the performance until the diagrams are as nearly correct as possible. He may have to move the tripping cams to equalize the cut-off. However, it will pay him to persevere, for the diagrams show a good opportunity for improvement.

J. Burns.

Columbus, O.

Boiler and Engine-room Ventilation and Drinking Water

Every boiler room and every engine room should be so designed that a good-sized monitor in the roof will give proper ventilation. The heat arising from the boilers and engine cylinders naturally goes to the highest point of the room, and this heat cannot escape unless proper provision is made for it to do so. The ordinary engine room of an industrial plant generally looks as if it were the last thing thought of in the construction of the plant, and then it was built on to some other building like a lean-to.

When laying out a new plant, the power equipment ought to come first; the engine room should be sketched on paper and the sketch studied very carefully, so as to provide plenty of room around the engine and condenser.

I was in charge of an engine room where 16 inches had been allowed between the sides of the cylinder and the wall. It was necessary to squeeze through there hundreds of times a day, and when it was required to repair the valves, they were taken out through holes in the wall.

Engineers and firemen, as a rule, cannot afford to go to the mountains or seashore in summer, but are compelled to sweat away their lives 12 hours a day in a little room in which the temperature ranges from 90 to 120 degrees.

In regard to drinking water, through mistaken economy black iron pipes instead of galvanized are used, and the water coming through this is often rusty and filthy. Is this kind of water calculated to quench thirst and revive a tired workman? Is it a wonder there is so much sickness among workingmen when their drinking water is polluted?

In some industrial plants, in order not to have to pay for city service, the water is pumped in from small ponds that probably contain every germ imaginable.

Ventilation and pure water are two things we need badly.

Oscar F. Broden.

Cleveland, O.

Paralleling Alternators under Odd Conditions

We have two stations, one containing two boilers and an engine belted to a short shaft which is connected to a main shaft by means of a clutch. The main shaft runs the length of the engine and generator room, and drives two 150-kilowatt, three-phase, revolving-armature alternators, with Tirrell voltage regulators. Connection is also made by means of a pulley and clutch to a water-wheel. The other plant comprises a 150-kilowatt, revolving-field alternator direct-connected to a water-wheel, and also controlled by a Tirrell regulator. This station is designated as the "upper plant," and the other the "lower plant." Two generators are often run in parallel, sometimes the two in the same plant, and sometimes one in each of the plants, wholly by water or by steam and water. The direct-connected plant has the use of the water first, and as the load often exceeds its capacity the other plant has to help out.

If the lower plant has a supply of water, the generator is started by operating the water-wheel by hand until about the desired speed is acquired. Then the voltage is built up until it is slightly higher than that of the line. The generator is then brought into step and thrown into parallel. At this time the upper or direct-connected plant is runing with its voltage regulator and water-wheel governor in use.

The operator at the lower plant has a receiving panel connected to the upper plant by means of which he can observe the load and voltage carried, and judge what proportion of the load he wants the lower plant to carry; he simply opens up the gate of his water-wheel until he gets that proportion. If he has a sufficient supply of water and the upper plant has not, he opens his gate until he takes the greater portion of the load, or *vice versa*.

The upper plant takes care of all speed changes and controls the voltage as well as the speed at the lower plant. As the load changes back and forth on the main line, the operator slightly changes his rheostats, so as to maintain the proper division of the total load.

When the engine is used with the upper plant, we first parallel the generator with the water-wheel, as there is a better chance to control the speed. After being connected, the engine is clutched in and the water-wheel is disconnected. The man at the upper plant is notified and he cuts out his water-wheel governor, and adjusts the water by hand until the proper load is carried, according to instructions given by the operator at the lower plant. In this case the engine takes care of the changes in speed and load.

When the upper plant is without water it is tedious at times to get the right speed, especially if in a hurry. Another point we have to watch out for is to see that the voltage on the incoming generator exceeds that of the line slightly so that when thrown in it will immediately take a portion of the load. If the generator voltage is lower than that of the line when thrown in it will only tend to load up the other generator. This, of course, applies to hand regulation, when the power cannot be increased at the instant you throw in.

J. W. Horner.

Keene, N. H.

Advice Wanted on Changing Condenser System

We have a cylindrical surface condenser, composed of 5/8-inch brass tubes, with about 2200 square feet of cooling surface. We have to use a cooling pond for circulating water. In the summer the temperature of this water gets up to about 100 degrees Fahrenheit, and, in consequence, the vacuum often drops to 20 inches.

Having been told that a condenser using the "dry and wet" system will give about two inches more vacuum with circulating water at about 100 degrees, we propose to change our condenser to the dry and wet system. We would like to inquire whether this is practicable.

Fig. 1 herewith shows the condenser as at present arranged and Fig. 2 the proposed arrangement. Our pump is of the Conover type, belt-driven, and was formerly used as a jet condenser. It was made by the Minneapolis Steel and Machinery Company.

W. H.

Minneapolis, Minn.

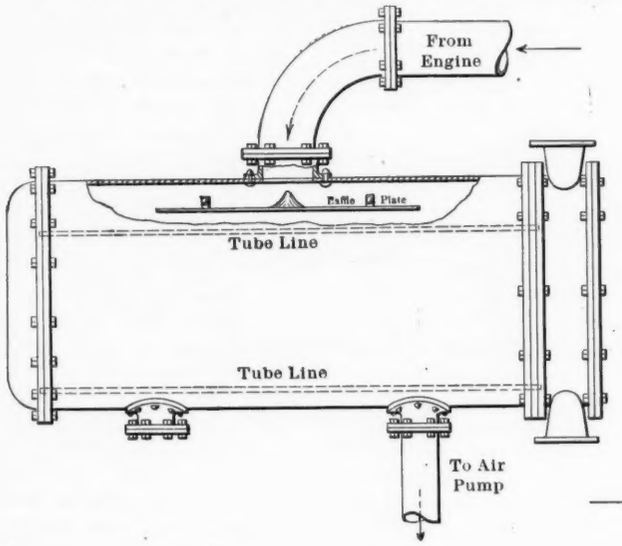


FIG. 1. PRESENT ARRANGEMENT

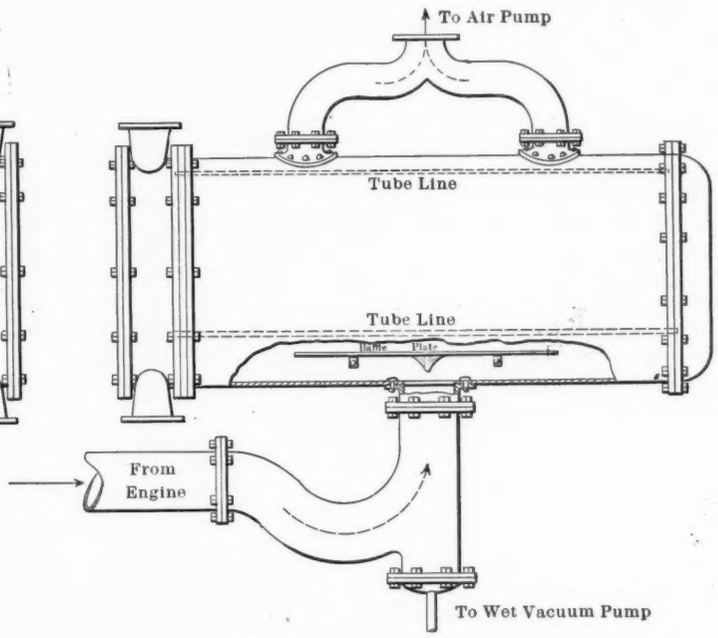


FIG. 2. PROPOSED ARRANGEMENT

Home-made Wooden Tongs for Handling Fuses

We use a number of protective fuses of the cartridge type, the fuse blocks being screwed on the back of the switch board. In order to replace burned-out fuses, it is necessary to reach in past exposed bus-bars that carry current at 625 volts and 125 volts, respectively. The generators are of the 2300-volt type, and there are three cartridge fuses to protect the potential transformers of each machine. These fuses blow out quite often, in synchronizing the machines, and sometimes they have to be replaced while the current is on.

TONGS FOR HANDLING FUSES

To avoid accidental shock we have had some wooden pliers or tongs made, to handle the fuses with, as per the accompanying sketch. The tongs comprise two pieces of oak, 1 inch thick and 1½ inches wide, the handles being rounded with a plane. The jaws are tapered for a distance of 3 inches to about 1 inch at the ends. The pieces were clamped together, and a hole bored laterally through the jaws, near the end as indicated, so that half of the hole is in each jaw piece. This hole is just the size of the smallest fuse. A piece of strap-iron was riveted on each side to form the hinge, there being two rivets in one leg to keep the parts from "sawing" back and forth.

Riverton, Ill. J. W. M.

Mishap to Generator Caused by Improper Grouting

In a street railway power station of about 6000 kilowatts capacity the load had increased to a point where additional equipment was imperatively necessary. The old machines had been badly overloaded for some time, but the need of uninterrupted service prevented repairs being made on them. Finally it becoming too apparent that they would not be able to carry the load much longer, a 1500-kilowatt three-phase revolving-field alternator direct-connected to a horizontal cross-compound engine was purchased.

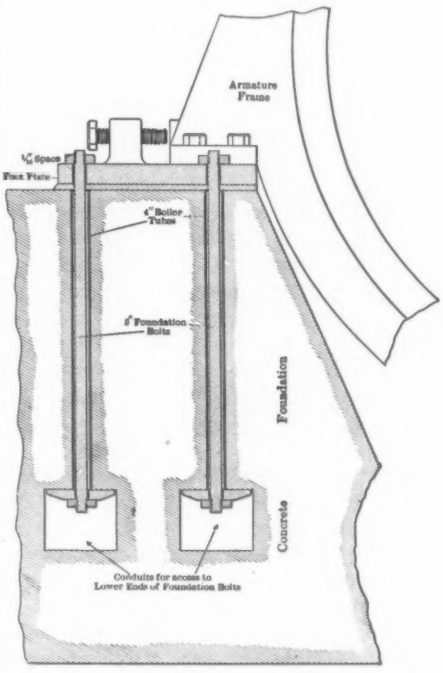
When the concrete foundation was made, previous to installing the new generator, a wooden templet was used to locate the foundation bolt-holes. Old boiler tubes of an inside diameter about one-half inch larger than the diameter of the bolts were secured to the templet to serve as bolt-holes, and at the same time allow slight clearance for adjustment, in case the templet should become displaced, or should the holes in the foot-plates vary slightly from the locations given on the blueprints. The accompanying sketch shows the arrangement of the tubes and bolts. The final adjusting and the grouting were done by the erecting engineer, and, as he seemed thoroughly competent, little attention was paid to these details by the busy men in charge of the station.

The boiler tubes which formed the foundation bolt-holes were left in the concrete, and when the erecting engineer grouted under the foot-plates of the generator he used thick cement, which failed to run down into the clearance spaces left between the bolts, and the inner sides of the tubes; this, however, was not discovered until later. After the new machine had been run by the erecting engineer for a few days without sign of trouble, it was turned over to the regular operating force.

Shortly afterward another unit of nearly the same capacity was taken out of service for repairs, leaving the station still badly overloaded on the morning and evening peaks and depending almost entirely on the new outfit to carry the load at all, on account of the sub-stations having no other source of supply. About 9 p.m., on the second day after this machine was taken out of service, a sub-station operator none too familiar with his new duties opened the field switch before switching the alternating current off at the machine, when cutting out a rotary converter. This produced a short-circuit on the alternating-current line, and caused the other rotaries to flash over, adding to the amount of current taken momentarily. The magnetic reaction created in the generator was so strong that it caused the stationary armature frame to slide on the foundation, owing to the foundation bolts being free to move in the boiler tubes, and this allowed the revolving field to rub on the armature core. An unearthly noise resulted, and the machine emitted fire and smoke like a miniature Vesuvius. The regular operator happened to be near the switchboard and, without stopping to investigate, opened the main and field switches. This stopped the disturbance, as there was enough spring in the frame to make it clear the revolving-field magnet when the current was off, and it took only a few minutes to discover the cause of the trouble.

It was essential that the machine be in service by 7 a.m., as the cars operated from that station were normally "packed to suffocation" by that time, and although the company had more cars and was willing to run them, there was not always enough power available to handle the regular schedule. Therefore the loss, even for a few hours, of a 1500-kilowatt unit, which was depended upon to furnish 2000 kilowatts or more during the peak loads, would be akin to a calamity. Furthermore, one of the other large units was dismantled and some of its parts in a machine shop miles away. So it was "up to" the operating force to "get busy." There was a traveling crane at the station, but it was a small hand-power affair that could not even lift the full weight of the armature frame. Nevertheless, the nuts were taken off the foundation bolts, as much load put on the crane as was considered safe, and the frame was forced back to its original position by means of screw jacks. It was found that while no serious damage had occurred, the laminations were pretty well jammed together in some places.

The next step was to anchor the machine so securely that it would never shift again. It would have taken several days to chip out the old grouting, put in new cement and let it set, so that suggestion was quickly rejected. There was only about one-sixteenth of an inch of space where the foundation bolts came up through the foot-plates, so cement could not well be used to fill the holes, unless so thinly mixed that it would make a poor job. Then, too, there was not time to allow it to set. The engineer had some



SHOWING ARRANGEMENT OF TUBES AND BOLTS IN GENERATOR FOUNDATION

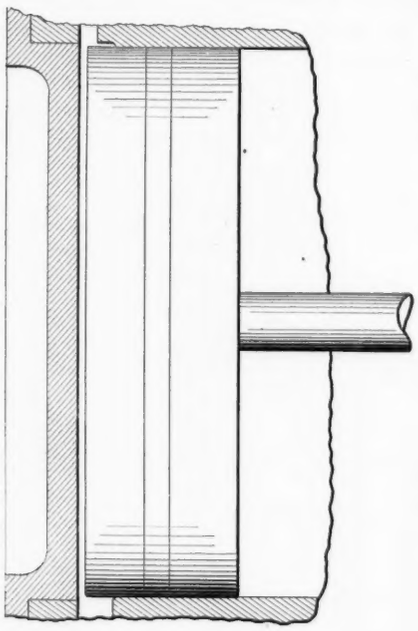
sand sifted very fine and with it filled the spaces around the foundation bolts to within about 18 inches of the top, probing with a small wire to determine when the proper hight was reached. In the meantime he had procured about a bushel of sulphur from neighboring drug stores, and this was melted in a tea kettle and poured into the openings until the tubes were filled to the top. The sulphur hardened very quickly and the generator was ready for service before it was required.

St. Louis, Mo. H. R. Mason.

Cause of Knocks in Old-time Corliss Engines

The sketch shown herewith is to illustrate a condition not uncommon in the older makes of Corliss engines, and I know of two instances in which it caused considerable annoyance. In each case the cylinder had been rebored and fitted with a new piston, but the counterbore, being left untouched, was not much larger than the bore of the cylinder proper.

In the first instance the piston fitted so snugly that a postal card could barely be slipped between the bull-ring and the top wall of the cylinder. The job had been carefully done, yet at the head end of each stroke there was a decided thud, followed by another less distinct. After the annoyance had lasted several weeks a thorough



CYLINDER AND PISTON OF AN OLD-TIME CORLISS ENGINE

examination showed that for about three inches from the head end the top wall of the cylinder was worn bright, although for a like distance on the bottom the tool marks from reboring were plainly visible; the rest of the cylinder showed the reverse, the bottom side being bright and the top unworn. This seemed to demonstrate conclusively that at or near the end of the stroke something threw the piston upward against the top wall, from which it dropped a little later, thus causing the double thud referred to.

In the sketch it will be seen that the wide exhaust port on the bottom reaches farther into the cylinder than the narrow steam port on top, thus allowing a certain area on the lower side of the piston to be exposed to an upward impulse from a compression near the end of the stroke. Perhaps, also, the quickly admitted steam crossed the cylinder and filled the exhaust port before it filled the small space in the counterbore surrounding the piston. Of course, as the piston moved from the ports, and as the pressure in the counterbore became equal all around it, the piston again dropped the thickness of the postal card to the lower side, but on account of the forward speed of the piston this was not completed until about three inches from the end of the stroke. A similar double knock was at times barely audible at the crank end of the stroke, but here the gland packing helped to hold the piston true. Enlarging the counterbore would doubtless have stopped the trouble. Instead of this, however, the bull-ring was slightly shifted on the spider so as to allow scarcely any play of the piston up and down. This stopped the knock, but for how long I do not know.

In the second instance the man who fitted the piston must have had a similar experience; for he made the bull-ring so snug that it stuck and scored the cylinder. Not being a bad case of scoring, however, it was decided to take as light a cut as possible off the bull-ring and let it go. But after this was done there was a double knock at each end of the stroke, and it continues to be heard to this day, seeming ever to say: "Counterbore me, counterbore me."

Litchfield, Ill. J. C. NICHOLSON.

Ignorance in the Generating-room

I was once "unfortunate" enough to be engineer in an old-time electric light plant which consisted of five engines downstairs and a collection of nearly every variety of dynamo upstairs. One machine was quite a puzzle for a while, owing to the fact that although a single-phase alternator, compound-wound, it would not maintain its voltage during a heavy load. Upon inquiring into its history I found that it was made for an 1100-volt machine, but the two sets of conductors which were originally in parallel had been connected up in series, raising the voltage to 2200.

The series-field winding consisted of the usual number of coils, but these were divided into two groups, the coils of each group being in series and the groups in parallel. When the armature was rewound the capacity of the machine in kilowatts was not changed; therefore the amperes were decreased with the higher voltage, thus decreasing the ampere-turns in the series-field winding. Why the two groups of coils were not connected in series when they changed the armature winding I could not learn, but upon doing this the trouble with low voltage on that machine disappeared.

Another time I worked a few days in an old power plant which comprised a 30x60 engine and a 1000-ampere 550-volt generator. The night man, who very obligingly showed me around the place, said that he believed the brushes on the machine ought to be shifted ahead, at the same time proceeding to do so to the extent of three inches. I thanked him for his trouble and looked forward to a lovely day. Everything worked all right except with a light load, when the brushes sparked considerably. This trouble became lessened on the afternoon load, however, and I began to think all was O.K., when another power house on the system became disabled suddenly and threw its load on us. That caused our circuit-breaker to blow out and then the fireworks commenced.

When the load went off, the machine proceeded to flash over. Talk about an eruption! Mount Pélee was not in it with the smoke that machine made. I shut down, called up the chief electrician, and told him we were burned up. On looking the machine over, however, I found that besides burning the grease and dirt out of the leads no damage had resulted. I started up again and got on the line, but not without first moving the brushes back to their original position.

At another plant there were two 100-kilowatt 550-volt machines in parallel with two 1000-kilowatt rotary converters. That was in the early days of 6600 volts in this "neck of the woods," consequently the voltage was an uncertain thing at times, for with only load enough for one large engine, every time the low-pressure piston would make the down stroke the voltage would go up, and *vice versa*. Three hundred amperes variation each revolution did not bother the converters, but with our little dynamos it was a different story.

One day there was a new man in the engine-room when the voltage on the rotary converters began to rise. This, of course, caused the dynamos to run as motors. They flashed over two or three times and the engineer promptly tried to shut the engine down, but the reversal of the direction of current through the series-field windings had weakened the field magnets and the engines ran faster than before.

The operator in the converter-room was attracted by the extraordinary bombardment going on in the engine-room. He came in and pulled the main circuit-breakers out, which stopped the fireworks, and, incidentally, the engine. He looked for the engineer and found him on top of the boilers shutting off the main stop-valve. The engineer remarked that a "live coward was better than a dead hero any day;" then he quit and got a job in a sausage factory.

I am not sure but what I would make my share of mistakes in electrical work, for I am not what might be termed an expert in that line. But, honestly, I am convinced that I could do better than some who pose as such.

Kansas City, Mo. ROTARY.

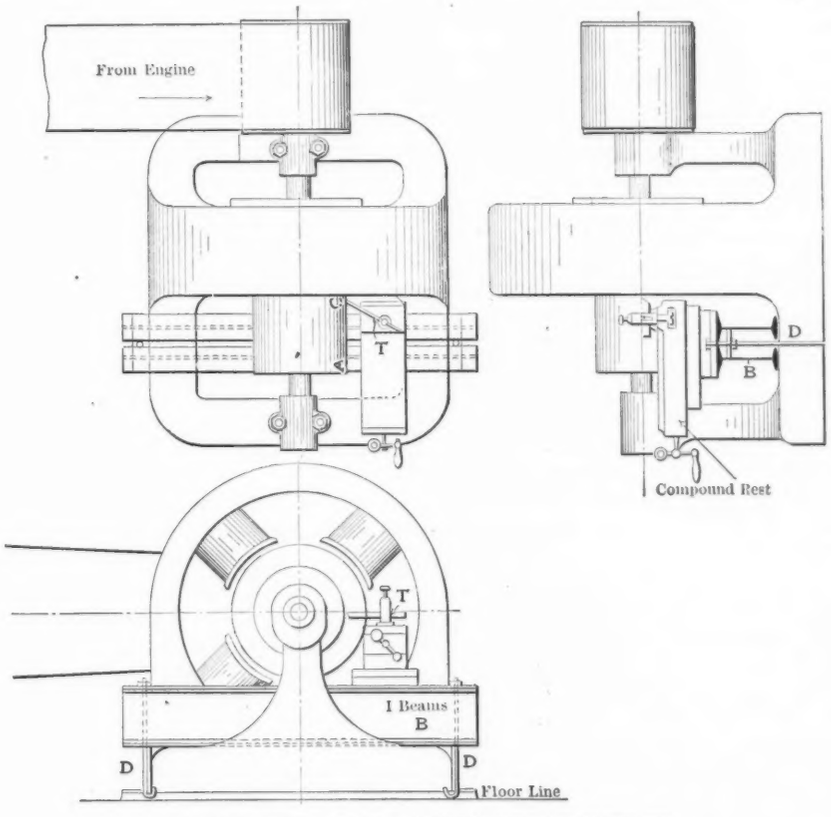
A Point of Etiquette in the Engine Room

Would it be proper for an assistant engineer to take cards from engines during his watch, with his own indicator, without consent of the chief? I hope some of those who have an assistant or assistants will give me their ideas on the subject.

Newburyport, Mass. H. H. H.

Truing up a Commutator

The accompanying sketch shows how the commutator of a fair-sized dynamo was trued up. The armature was heavy and the machine shop far away, so the compound tool rest of a large lathe was made the portable tool. Two I-beams *B* were placed on the frame of the dynamo, as shown, and held in position by means of the bolts *D*, which were bent at the ends to go around the dynamo frame. The compound tool post was bolted to the beams and lined up with the armature shaft by putting a tool *T* in the tool post



ILLUSTRATING HOW A COMMUTATOR WAS TRUED UP

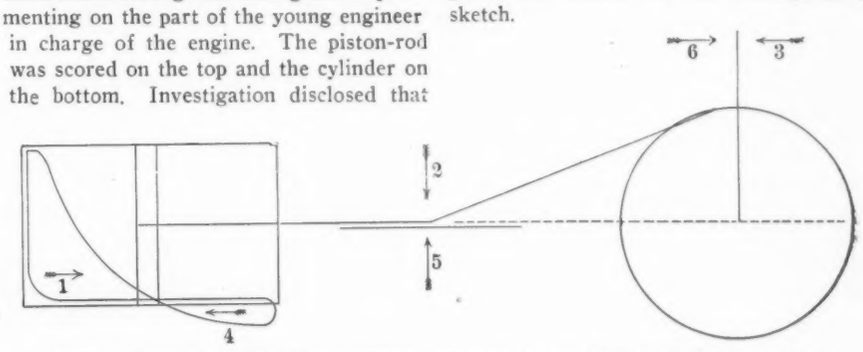
and making the end of the tool touch at the points *A* and *C*. These points not being under the brushes, the original diameter was unchanged. The engine was run as slowly as possible without stopping, and the tool was fed across the face of the commutator. A roughing and a finishing cut were necessary.

Allentown, Penn. JOHN I. BAKER.

Piston-rod and Cylinder Scored in Odd Manner

I once had a rather peculiar experience with a scored piston-rod and cylinder. It came about through theorizing and experimenting on the part of the young engineer in charge of the engine. The piston-rod was scored on the top and the cylinder on the bottom. Investigation disclosed that the intermediate bolts which held the top guide bars in place (the engine had the marine type of crosshead) were loose, and had become unscrewed for a short distance from the bars. The bars were light, and there were five bolts to each, one at each end and three between.

Upon inquiry, it developed that the engineer had purposely slacked up these bolts to see if the engine would run all right that way, just for an experiment. As the engine ran over, he was justified theoretically, at least, in the belief that the crosshead would stay on the bottom guides throughout the stroke; but he did not consider the other conditions under which the engine was operated. The load was intermittent, there being at times scarcely any load at all, on which occasions, naturally, the cut-off would be short and the expansion drop below atmospheric pressure, forming a loop in the indicator diagram, as shown in the accompanying sketch.



ARROWS INDICATE STRESSES ON PISTON, CROSSHEAD, CONNECTING-ROD AND CRANK

When this loop is formed the stresses on the piston, crosshead, connecting-rod and crank change from a push in going over to a decided pull, as the fly-wheel has to carry the piston forward against a pressure, with more or less of a vacuum behind it. Of course, this pull from the fly-wheel and the opposing pressure at the piston cause the crosshead to lift, just the same as if the engine were running under.

The illustration shows how these stresses are set up: Arrows 1, 2 and 3 indicate the stress of the steam; arrow 1 shows the steam pressure on the piston up to this part of the stroke; arrow 2 shows the downward pressure on the guide during the time the steam pressure is behind the piston, while arrow 3 indicates the load pressure to be overcome. Now, when the expansion line runs down below the atmospheric line, we have the pressure indicated by arrow 4 for the piston to overcome, while at the same time there is more or less of a vacuum behind the piston. It is now plain that the stresses between arrows 3 and 6 must change places, for the fly-wheel must pull the engine on against the pressure in front of the piston, or stop. As it does not stop, but keeps on pulling, it is evident that the stresses between arrows 2 and 5 must interchange and the crosshead has to lift if there is any chance for it to do so.

In the light of the observations it becomes quite clear why the engine mentioned should score its piston-rod and cylinder in the manner stated. With the guide bars so they could spring when the stress came on them, it was a matter of course for the crosshead to lift, cramping the piston-rod in the stuffing-box and jamming the piston on the bottom of the cylinder.

The sketch makes it clear also why the negative loop area of the indicator diagram should be subtracted from the effective area when computing horse-power.

JAS. W. LITTLE.

Oregon City, Ore.

Boilers in a Government Vessel in Bad Shape

In July, 1903, the United States collier "Brutus" arrived in Pago Pago (Pango Pango), Samoa, long overdue, with a cargo of coal for the naval station on the enchanted isle of Tutuila. Upon arrival the captain reported considerable boiler-room trouble, including the collapsing of three furnaces, splitting of more than two hundred tubes and several other mishaps. This vessel was manned by a merchant master and crew, and the writer was serving in the capacity of chief machinist on the U. S. S. "Wheeling." The latter being in port at the time, I was detailed to inspect the boilers on the "Brutus" before they were cleaned.

It requires a more facile pen than mine to describe adequately the conditions I found. Three of the corrugated furnaces were "down" so bad that one boiler had been cut out entirely and the pressure reduced on the other. The tubes that leaked were perforated with numerous small holes that looked as if they had been drilled with a No. 24 drill and slightly countersunk. The shells of the boilers showed signs of deep corrosion and pitting everywhere. There was not a vestige of the zinc slabs that were supposed to be in the boilers, although the baskets and hangers were still in place.

The entire water space in each boiler was covered with from ⅛ inch to 2 inches of peculiar brown sediment and a crude analysis of some of the scale showed the key to what appeared to be a strange puzzle. The engineer in charge said that he first came aboard on the morning prior to sailing, when practically everything was in readiness for departure, and that although he had on several occasions requested time to clean the boilers, the captain refused to grant this request, as he had orders to hurry. The salinometer test showed a saturation of about 3/32 and the water was not allowed to become denser. The boat steamed to her destination around the Horn, a trip of about 15,000 miles, without giving the engineer an opportunity to clean the boilers.

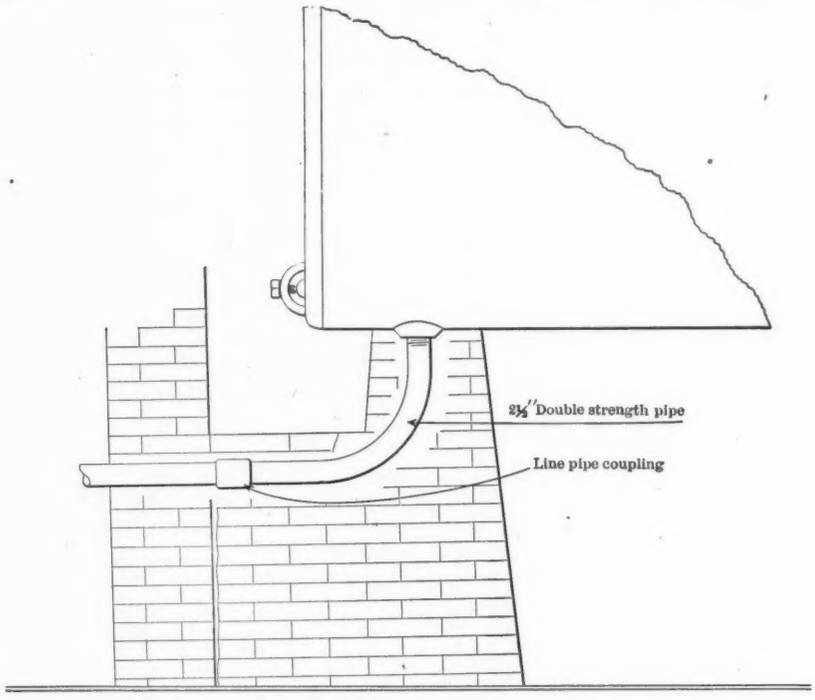
The brown sediment referred to was nothing less than copper paint, with which the double-bottom compartments carrying the fresh water for boiler-feed had been painted, and for some reason this paint had been scaled off and was of course taken into the boiler by the auxiliary feed-pump, or whatever device was used. The action of electrolysis caused by the copper present can only be conceived by an engineer who has had actual experience in this line. After decomposing the zinc plates, the corrosion next attacked the tubes, and in fact all the exposed metal. The boilers were thoroughly cleaned, re-tubed and new zincs fitted. A templet was made from light railroad iron by means of a portable forge and two 20-ton hydraulic jacks; the furnaces were put back to the true radius and several minor repairs made.

Chicago, Ill. GEO. W. BACH.

Feed and Blow-off Pipes

Inclosed find a sketch of our method of connecting up and protecting blow-off pipes on the boilers in my charge, which I believe is better than any shown in recent issues of POWER.

The pipe is inclosed in a brick flue, the top bricks of which are laid loosely, making inspection an easy matter. We have been using the extra heavy bent pipes for several years, with the best results, and consider them much superior to any arrangement which requires fittings in the furnace.



THE BLOW-OFF PREFERRED BY MR. BENEFIEL

All the boilers in this plant have handholes, as shown by the sketch, which is a great convenience in cleaning out, as it enables us to insert a roll of screen wire in the blow-off opening, which prevents the scale from getting down in the pipe and choking it when cleaning.

We were bothered by the nuts burning fast on the handhole-plate bolts. This we overcame by drilling and reaming the plate, driving in a bushing tapped almost through, thus getting the bolt threads where they would become no hotter than the water in the boiler.

The first few years of my experience all the boilers I came in contact with were fed through the blow-off, and I cannot remember that this method ever cost 50 cents for repairs, and do not believe it would in any case where the temperature of the water was 150 degrees or over. In our practice we never feed or fill up a boiler with cold water and believe that no one has less trouble with leaky tubes. In any method the regulating should be done from the front. If you want a thing attended to as it should be, arrange it as convenient as possible for the attendant.

A long time ago someone said a horizontal tubular should be fed through an internal pipe which entered above the flues, extended back the full length of the boiler, crossed over and went down somewhere, which is an ideal arrangement to choke up, and makes trouble for the man in charge, with no appreciable benefit. I believe there are a lot of fellows who think as I do about this, but for various reasons do not express themselves. It seems to me, however, that it would be helpful to us all, if some of them would be more outspoken on such matters.

It is also said that the water should enter the boiler at the coolest place, which likewise I do not believe. I want to be shown why this should be so, and why it should not be fed in at the hottest part of the boiler.

I once fired a locomotive boiler which took its 30-grain solution of lime and water in at the coolest place, in this case the water leg. Any time the water was going in you could hold your hand on this part of the boiler without the slightest discomfort, unless the water was unusually cold.

Now, I hope those who read this letter will not consider the topics unworthy of consideration; but that some of them at least will write and let us know what they think.

Anderson, Ind. J. O. BENEFIEL.

A Symposium on Superheated Steam

Discussion of Papers Presented at the Spring Meeting of the American Society of Mechanical Engineers, at Indianapolis

The feature of the spring meeting of the American Society of Mechanical Engineers, from the POWER point of view, was a symposium on superheated steam. The scientific, or theoretical, side of the question was treated in three papers: "Specific Heat of Superheated Steam," by A. R. Dodge; "Flow of Superheated Steam in Pipes," by E. H. Foster, and "Entropy Lines of Superheated Steam," by Prof. A. M. Greene. These were presented and discussed together.

Mr. Dodge's paper gave the results of two independent tests for determining the specific heat at constant pressure for various pressures and degrees of superheat. In one method the superheated steam is cooled by the injection of water, and the amount of heat liberated by cooling the steam a measured amount determined by noting the rise in the temperature of the water. The second method makes use of the expansion of initially superheated steam in a throttling calorimeter. The investigation has been carried to pressures several hundred pounds above those of tests heretofore published, and both methods eliminate the uncertainty involved by an assumption of exactly dry saturated steam, and are free from errors due to inaccuracies in the total heat of steam as given in the steam tables. The author arrives at the conclusion that the specific heat increases with the pressure, but is constant for varying degrees of superheat at the same pressure, a conclusion with which many of those who took part in the discussion were inclined to take issue.

Mr. Foster had been able to collect enough data from a sufficient number of plants to indicate that the laws governing the flow of superheated steam differ appreciably from those governing the flow of saturated steam. His general conclusions were:

That the rate of heat transference per degree difference in temperature per unit area of surface increases with the steam velocity.

That this increase is more rapid in small than in large pipes.

That the percentage loss of heat decreases with the velocity, notwithstanding the rising rate of heat transfer, as, although more heat is radiated, it is a smaller proportion of the greater amount of steam passing.

His practice was to recommend for steam pipes of straight runs or easy bends a velocity of from 6000 to 8000 feet per minute, where a superheat of from 100 to 200 degrees Fahrenheit is used. The loss in temperature in Fahrenheit degrees for 100 feet of pipe is quoted from the paper presented to the German Society of Engineers by O. Berner for an average steam pressure of 176.5 pounds at a temperature of 482 degrees Fahrenheit, which is 105 degrees of superheat, as follows:

LOSS IN TEMPERATURE FOR 100 FEET OF PIPE.

Diam. Pipe in Inches.	Velocity of Steam in Ft. Per Min.		
	1968	3936	5904
3.937	50.3	25.5	16.45
7.874	25.5	12.7	8.23
11.811	17.0	8.23	5.49
15.748	12.6	6.07	4.39

Diagrams showing the drop in temperature per hundred lineal feet of pipe, and the variation of heat transfer with velocity, are given, together with a diagram showing the pipe area required to pass 1000 pounds of steam per hour at different degrees of superheat and at different velocities.

Professor Greene's paper on "Entropy Lines of Superheated Steam" is based upon the recently published account of the experiments of Knoblauch and Jakob. The results of Grindley and Griesmann seemed to indicate that the specific heat increased with the temperature, and was independent of the pressure. This was found to be untrue in the various experiments of Lorenz, Linde, Holborn and Henning, Callendar, Carpenter, Knoblauch and Jakob. The latter experimenters found the specific heat to increase with both the pressure and temperature, and their results are given in both tabular and graphical form.

The entire report is to be found in the *Zeitschrift des Vereins Deutscher Ingenieure* of the present year.

The method of using the curves for the determination of the total heat required to superheat a pound of dry steam is explained. This is followed by a simple graphic method of computing the entropy change from one temperature to another, and by an approximate analytical method which gives close results. These results are then plotted on a temperature entropy diagram on which the lines of the total heat are also plotted. The curves are plotted on a scale of temperature of Fahrenheit degrees and Centigrade degrees, and a method of passing from lines of constant pressure of integral number of kilograms to an integral number of pounds is developed. There are included in this paper tables of entropy change from the saturated point to any point of superheat for the purpose of utilizing the results of the paper for the construction of superheat lines on entropy diagrams constructed from steam tables other than the one used in the paper.

Prof. Sidney A. Reeve was the first to question the truth of Mr. Dodge's conclusions. He could not check his calculations of the results by the water method within 5 per cent. His (Reeve's) figures were uncertain to the degree that the temperature of the injection was not stated by Mr. Dodge, but it would have to have a temperature of 66 degrees below zero Fahrenheit to give the results presented by Mr. Dodge. He did not agree with Mr. Dodge's conclusion that "temperature has an inappreciable effect upon the value of C_p (the specific heat at constant pressure). Statements of the variation in terms of the temperature can have meaning or usefulness only when comparisons are made at constant pressure. Few of Mr. Dodge's experiments were made under these conditions, but those which were show an increase of C_p with the temperature.

The results from the throttling test are equally open to question. Mr. Dodge bases his conclusions upon the straight line obtained when the relation of the initial and final temperatures of the throttling calorimeter are plotted, "but," says Mr. Reeve, "this function can be a straight line only approximately and over a limited field. The straight-line hypothesis is valuable in that it further corroborates the evidence already in hand that the saturated condition dies out, as steam is superheated, quite gradually. But it may not be accepted as a law, because it is the most questionable in a field so difficult that Joule's first efforts failed to perceive any temperature differences at all, where Lord Kelvin's skill was requisite for satisfactory results, and where Mr. Dodge's methods, which are most commendable for moderate superheats, are the worst imaginable for showing up these particular points. What the profession wants is a checker-board crossed by constant-pressure and constant-heat curves, with the value of C_p marked on each section of each constant-pressure line, showing the value prevailing for that locality in the diagram."

In view of the confusion in which the subject is clothed after so much experimentation, Professor Reeve suggested the appointment of a committee and the calling upon the Government for funds to "put the thing through aright."

Prof. R. C. Carpenter, who has done a

large amount of work upon the subject, at Cornell, thought that when the question was finally determined, the values of the specific heat would be found to be considerably higher than indicated in Mr. Dodge's paper. The determination of the specific heat by the throttling calorimeter method requires that the amount of heat supplied at one pressure is equal to that found in the calorimeter at the lower pressures, provided that all losses are eliminated. It is evident that the accuracy of the results must depend upon the accuracy with which the quality of the original sample and the heat losses in the calorimeter are determined. Experiments made under Professor Carpenter's direction by Stewart and Marble, in 1891, by this method, gave for the specific heat of superheated steam at atmospheric pressure:

$$C_p = 0.46305 + ap,$$

where a is a constant and p the absolute pressure in pounds.

The results indicated an increase of the specific heat with increase in pressure, but showed no increase so long as the pressure remained constant for increasing amounts of superheat over a small range.

There was reason to think that the heat loss and the initial condition of the sample were not determined with sufficient accuracy, and Professor Carpenter had the experiments repeated the following year by Hoxie and Wood. In both cases an initial condition of saturation was sought by first superheating the sample and then passing it over the surface of water. These experiments indicated an increase in C_p with increase of pressure, but no increase in its value due to increase in the degree of superheat.

In 1898 E. C. Sickles, now mechanical engineer with Westinghouse, Church, Kerr & Co., repeated the experiments in a post-graduate course, with better facilities and using superheated instead of saturated steam in the initial stage of the calorimeter. Mr. Sickles' work checked, so far as variation is concerned, with the previous experiments, but the field covered was very narrow.

In 1900 Prof. C. R. Jones spent a year at Sibley and Professor Carpenter interested him in the problem. The results of his experiment indicated:

$$C_p = 0.462 + 0.00065\ p.$$

He next considered the method of heating steam from one degree of superheat to another electrically, measuring the electrical energy required. M. E. Berry, Fellow in Sibley, worked a full year in 1904-5 in developing this method. His difficulty was in accurately measuring the temperatures because of the change of zero points in the platinum resistance thermometer which he used. For the ranges of pressure and temperature which were available his results indicated an increase of the specific heat with pressure and decrease with increase in the temperature of superheat, as follows:

$$C_p = 0.48 + 0.0056\ p.$$

The year following Prof. Carl C. Thomas undertook the solution of this problem with Dr. Whitney, at Schenectady, and later at Cornell, with improved facilities largely furnished by the General Electric Company. He was assisted by C. E. Burgoon, Fellow in Sibley College, and employed the method used by Mr. Berry. The results showed an increase in the specific heat with increase of pressure and a slight diminution with increase of temperature, as reported in his paper on "The White Steam Car," at the last meeting. The results of these investigations indicate that:

For 5° superheat, $C_p = 0.48 + 0.0007\ p.$
For 100° " $C_p = 0.48 + 0.006\ p.$
For 180° " $C_p = 0.48 + 0.0005\ p.$

The facilities of the laboratory did not provide steam above 250 pounds. The White Steam Car Company loaned a boiler and during the past winter Professor Thomas, with the assistance of F. J. Short, M. E., Fellow in Sibley College, continued the experiments over a range of pressure to 600 pounds, and of temperature to 300 degrees superheat.

Here again accurate measurements of temperatures and qualities were the points of greater difficulty. The only thermometers which proved suitable were of the thermal-junction type, in which the elements were nickel steel and constatin. The results obtained were in substantial agreement with those obtained the year before. They are considerably higher than those reported by Mr. Dodge, and are believed to be very accurate. Professor Thomas expects to present an account of the investigation, with his results, at the fall meeting of the society.

Frank C. Wagner said that while Mr. Dodge reaches the conclusion that the specific heat of superheated steam does not vary with the temperature, but does with the pressure, yet we find in the table from which he deduces these conclusions such results as these: At a pressure of 110 pounds, C_p ranging from 0.48 to 0.496, while with the low pressure of only 9 and 10 pounds the specific heat is 0.497. Apparently over that wide range of pressure, from 10 to 110 pounds, there is practically no variation in the specific heat. In other experiments where the range of pressure is even less, he gets variations in the specific heat of from 0.49 to 0.54. The truth of his deduction that the specific heat does not vary with the temperature depends upon the constancy of the specific heat at atmospheric pressure. If this is variable, then the deduction is not true. Knoblauch and Jakob find that the specific heat at atmospheric pressure is not constant, that it varies widely—from 0.46, as he gives it, at a temperature of 100 degrees Centigrade, up to 0.511 at 400 degrees Centigrade.

Prof. D. S. Jacobus concurred in what Mr. Wagner said. The conclusion could not be deduced from the observations, even assuming that the experiments had been carried out with absolute correctness. He had worked with apparatus very similar to that described by Mr. Dodge, but had never thought his results worth publishing. The whole trouble is that you cannot get rid of the film of moisture which runs along the pipe. When you inject water into superheated steam, it has a very peculiar action. You can take every precaution, and finally you will drain that water out of the bottom of the pipe. He had made experiments with the throttling calorimeter, but had never published them, because he had learned that it was next to impossible to get the correct temperature of steam. He pointed out that Mr. Dodge says his results do not depend upon the values given in the steam tables, and he has in his tables two values for total heat. Mr. Foster draws attention to the fact that the heat lost in saturated steam is not exactly comparable with the heat lost in the transmission of superheated steam, because if you get heat loss in saturated steam you can draw out the water. Mr. Berner shows conclusively that you may have condensation in superheated steam pipes, and the results of other experimenters show that you can have condensation where you have a very high degree of superheat, running from 10 to 60 per cent. Furthermore, in these experiments it appeared that with different velocities in the same pipe you get practically the same loss per square foot. Mr. Berner went in to find the real gain at the engine and in one case he got 1 per cent. gain by using superheat, and in another 2 per cent. loss. This must have been transmission loss. Theoretically you can get lower heat consumption with superheat than with saturated steam, but when it comes down to the engine he shows that you get little advantage from superheated steam.

Hosea Webster, of the Babcock & Wilcox Company, said that all evidence points to the fact that, excepting where the cooling is excessive, the steam in a pipe has a superheated core, and a gradually falling temperature outward until there is an annulus of condensate at the inner surface of the pipe. The disagreement in the conclusions of the different experimenters is due to the difficulty of obtaining accurately the temperature of superheated steam. The fact that almost without exception pipes conveying superheated steam contain more or less water of condensation at the same time raises the question whether the temperature of the pipe itself exceeds the temperature due to the pressure carried, and whether sufficient care is taken to insulate the thermometers against the cooling effect of the pipe. He suggested that in future experiments, observations should be made of the following:

Hourly steam weight conveyed through the pipe.

Hourly condensation in the pipe.

Steam pressure at the beginning and end of the pipe line.

Steam temperature at the beginning and end of the pipe line when the observations refer to superheated steam.

Quality of steam at the beginning and end of the pipe line where the observations refer to saturated steam.

Professor Goss expressed his gratification at the presentation of information concerning the specific heat of superheated steam from three sources, Schenectady, Munich and Ithaca, and at the agreement of the results from Munich and Ithaca.

R. W. Stobel—in an endeavor to answer the question, "What is the most economical amount of superheat for a given condition?"—describes a turbine station with economizers giving an average feed-water temperature of 250 degrees Fahrenheit, steam 215 pounds, in which with a fixed pressure and vacuum, there was a guarantee of 6 per cent. saving for 50 degrees Fahrenheit superheat, 10 per cent. for 100 degrees, 12½ per cent. for 150 degrees and 14 per cent. for 200 degrees. These relations are expressed in the following table:

RELATIVE STEAM CONSUMPTION PER UNIT OF DELIVERED WORK WITH VARYING SUPERHEAT COMPARED WITH THE CONSUMPTION AT SATURATED STEAM AS UNITY.

Saturated steam	100.0 per cent.
50 degrees F. superheat	94.0 per cent.
100 degrees F. superheat	90.0 per cent.
150 degrees F. superheat	87.5 per cent.
200 degrees F. superheat	86.0 per cent.

We learn from Mr. Dodge that the specific heat of superheated steam at 215 pounds is 0.54, and that it does not vary with the amount of superheat; that is, with the temperature. The heat units in a pound of steam with varying superheat are, therefore, expressed by the following table:

HEAT UNITS IN A POUND OF STEAM WITH VARYING SUPERHEAT.

Saturated steam	980
50 degrees F. superheat	1007
100 degrees F. superheat	1034
150 degrees F. superheat	1061
200 degrees F. superheat	1088

If we now make the assumption that for every heat unit taken out of the boiler in the steam a definite amount of coal is burned, that is to say, the coal efficiency of the boiler is the same whether the heat be taken out in saturated steam or superheated steam, then the amount of coal required to give varying superheat is in direct proportion to the amount of heat in the steam. From this we get the results shown in the following table:

RELATIVE AMOUNT OF COAL PER POUND OF STEAM WITH VARYING SUPERHEAT COMPARED WITH COAL REQUIRED AT SATURATED STEAM AS UNITY.

Saturated steam	100.0 per cent.
50 degrees F. superheat	102.8 per cent.
100 degrees F. superheat	105.5 per cent.
150 degrees F. superheat	108.3 per cent.
200 degrees F. superheat	111.0 per cent.

You now have in Table 1 the relative steam required per unit of work, and in Table 3 the relative coal required per pound of steam. Each refer to the same base, namely, the condition of saturated steam and each for the same variation in superheat. In other words, we have first what we get from each pound of steam, and, second, what it costs to get each pound of steam. Hence the product of these two relations gives us the relative amount of coal per unit of delivered work, which will tell us the amount of superheat for which we will burn least coal, and from the foregoing this is the amount of superheat, which will give the most economical results for the station as a whole, to be obtained by varying the superheat. This works out as follows:

RELATIVE AMOUNT OF COAL PER UNIT OF DELIVERED WORK WITH VARYING SUPERHEAT.

Saturated steam	100.0 per cent.
50 degrees F. superheat	96.6 per cent.
100 degrees F. superheat	95.0 per cent.
150 degrees F. superheat	94.7 per cent.
200 degrees F. superheat	95.5 per cent.

From this it will be seen that maximum economy due to the use of a superheated steam is obtained with about 150 degrees Fahrenheit, and that the economy is practically the same between the limits of 100 and 200 degrees. It is seen that in this case the maximum saving effected by superheat is about 5 per cent. of the coal bill, and hence if the coal cost is one-half the total annual cost, the maximum saving due to the use of superheat will not exceed 2½ per cent.

Max Toltz, engineer of the Great Northern Railway Company, in discussing Mr. Foster's paper, told of a test which he had made on a 2-inch pipe 800 feet in length, with steam of 90 pounds pressure and 100 degrees superheat. With a velocity of 6000 feet per minute the loss per 100 feet was between 6 and 7 degrees; with a velocity of 3000 feet per minute they lost the superheat entirely, the loss exceeding 12 degrees per hundred feet. In locomotive practice, notwithstanding the connection is very short, they lost out of a superheat of 100 degrees from 15 to 40 degrees; with a superheat of 200 degrees they lost only 10 to 25 degrees, all depending on the velocity of the steam. Running at 55 miles the steam acquired a velocity of 234 feet per second, and in that case they lost 10 degrees of superheat, while with a velocity of less than 100 feet per second they lost from 12 to 30 degrees.

Mr. Kinealy pointed out that high velocity was favorable to the superheat, but bad for reduction of pressure. It became a question which it was the better to sacrifice.

Mr. Kruesi asked Mr. Foster whether the 6000 feet per minute referred to was the working or the maximum velocity. Steam pipes for Curtis turbines were proportioned to give a velocity, at normal full load running condensing, of 4500 feet per minute, which would give a velocity of 8000 to 9000 feet at full load non-condensing.

Mr. Foster replied to Mr. Kreusi that the 6000 feet was the average velocity and provided for an overload of from 30 to 50 per cent., while a turbine is apt to carry an overload of 100 per cent., which would make the overload velocity in the turbine 9000 feet. He had noticed that in separately fired superheaters it is very hard to justify the high specific heat found by some of the experiments with the fuel consumption. If you assume a specific heat of 7.7, or over, you get too high an efficiency for the apparatus, 75 per cent., or so, while it should not exceed the ordinary boiler efficiency, and probably be not so good, owing to the higher temperature of the gases.

SUPERHEAT AND FURNACE RELATIONS

By Reginald Pelham Bolton

Most of our present practice appears to be based upon the adaptation of superheating apparatus to standardized forms of boilers and settings, a leading consideration being the avoidance of disturbance of their accepted design or alteration of the accepted relation of boiler parts.

Merely to place a superheating coil in a certain part of the gas passage of a boiler, and to connect the steam supply to it by strange and undesirable pipe connections, is by no means to be regarded as a complete solution of the problem. If its proportions be based upon a given heat transfer to a given rate of steam passage through its interior, then the addition of green fuel to the fire or other sources of heat variation there may affect its output to a very wide degree, with consequent wide variation in cylinder effect. Automatic firing may do much toward eliminating the fluctuations of gas flow and temperature, but even more appears to be realizable by the provision of some form of reverberatory construction, in which masses of arches or walls alternately absorb and give out excess heat. Desirable results seem on the face to be more readily attainable in the separately fired type of superheater, but in this form of the appliance the separate furnace is subject to many of the same effects of fluctuation due to fuels, drives and handling that a main boiler furnace would be. Moreover, the temperature at which the gases of a separate fire must pass off from the apparatus involve some loss in heat. This escaping heat might in some cases be utilized in an economizer or connected into the boiler gas passages at some suitable point. An ideal condition would, perhaps, be attained by gas-fired, independent superheaters connected in this manner to the boiler, a refinement, however, not generally practicable. The evident trend of general steam practice is toward the use of some degree of superheat, and the boiler of the future may thus be regarded as a combined apparatus involving fuel, air, furnace, generator and

superheater supplying with the same regularity and security with which commercially dry steam is now delivered a superheated steam of defined quality in any quantity up to its extreme capacity.

Hosea Webster objected to the author's arraignment of boiler builders, because they did not sacrifice everything to the superheater, and said that absolute constant temperature of superheated steam is neither a commercial nor a theoretical necessity, though it may be desirable for an engine carrying a constant load. It is perfectly feasible to construct a combination of steam generator and superheater which will supply superheated steam of any desired constant temperature in varying amounts, if the purchaser will eliminate all limitations of first cost and operating expenses. The temperature of the gas passages, and, consequently, of the output of a steam generator, varies with the volume and temperature of the products of combustion. Current practice, therefore, places the superheater as near the furnace as practical limitations of durability and accessibility will permit, where the changes in temperature are coincident with the variations in the furnace temperature, and the consequent variations in amount of steam to be superheated. The more steam there is made, the greater its velocity through the superheater, and hence, although the temperature of the furnace is higher when the boiler is being forced, the steam is not delivered any hotter, but is simply and automatically maintained at practically the same temperature. The slight variations which do occur, as between light and heavy firing, become insignificant in the majority of plants by the time the steam reaches the engine.

"No device has ever been so generally adopted which saves as much fuel with as low first cost and operating expense as the several standard superheaters of today."

As an example of what present forms of superheaters will do, the accompanying table of a test of one of the boilers at the Waterside station of the New York Edison Company shows a remarkably stable temperature. Numerous examples of as good a performance could be cited.

SUPERHEAT TEST AT THE WATERSIDE STATION OF THE N. Y. EDISON CO.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of Test.	Duration of Test. Hours.	Maximum H.P.	Minimum H.P.	Average H.P.	Per Cent. Builders' Rating.	Average Smoke Flue Temp. Deg. Fahr.	Average Steam Pressure Lb. Per Sq. In. Gage.	Saturated Steam Temp. Due to Pressure. Deg. Fahr.	Maximum Observed Superheat. Deg. Fahr.	Minimum Observed Superheat. Deg. Fahr.	Average Temp. of Superheated Steam. Deg. Fahr.	Average Superheat. Deg. Fahr.	Variation From 123.2°F Average Superheat of 7 Tests. Deg. Fahr.
13	10	625	570	608	93.5	499	181.9	380.3	116.8	96.8	489.5	109.2	—14.0
3	9½	736	596	652	100.0	497	182.0	380.4	132.9	119.4	506.3	125.9	+ 2.7
4	10	760	620	693	106.6	521	182.0	380.4	151.0	126.0	516.3	135.9	+12.7
8	10	758	645	704	108.1	521	182.4	380.4	127.0	106.0	496.3	115.9	— 6.3
2	10½	870	663	767	118.0	515	184.0	381.0	139.0	109.0	500.0	118.9	— 3.3
12	10	950	717	803	123.0	532	181.8	380.0	135.0	118.0	508.8	128.8	+ 5.6
1	8	950	775	860	132.0	493	182.5	380.3	139.0	114.0	508.3	128.0	+ 4.8

In 1904 36 per cent. of the horse-power output of the Babcock & Wilcox Company was equipped with superheaters, located in the gas passage, 41 per cent. in 1905, and 61 per cent. in 1906, with the indication that the percentage for this year's business will be considerably larger.

J. Rowland Brown said: "I believe I am safe in stating that the standard type in this country is that in which the heating surface is contained within the boiler setting. The boiler-setting type requires no additional space for its installation over that required for the simple boiler, except in cases where high degrees of superheat are required, and then an addition is made to the hight of the setting. It requires no additional steam piping over the simple boiler, except when it is required to operate the superheater as a part of the water-heating surface of the boiler. It has been customary to flood the superheater when raising steam or whenever the flow of steam through the tubes is stopped. In designs where the superheater is located at such a point in the setting that the average temperature of the gases does not exceed 1000 degrees Fahrenheit, it is not necessary to flood when raising steam if fair judgment is used. In one case a Babcock & Wilcox type boiler was shut down every night and started up rapidly each morning without flooding, and by a fireman who did not know what a superheater was. This superheater showed no signs of burning or leaking of the tubes. I have flooded and drained superheaters while the boiler was cut in on the load and never experienced any trouble from water hammer. The greatest danger of burning a superheater is when a boiler is being forced and for some reason is cut out of service. The result is that the pop-valves on the drums open and discharge the steam, and there is no flow through the superheater, although a high temperature is maintained in the setting, and if stokers are used, this condition may continue for some time before it is checked. To guard against this condition a pop-valve is placed on the superheater outlet.

"When a superheater of the boiler-setting type goes out of commission, it only causes the loss of the one unit, and the ratio of superheating to water heating surface in the remainder of the plant remains the same. When an independently fired superheater goes out of commission, it reduces the whole or, at least, a large part of the plant to saturated steam conditions.

"The objection that the boiler-setting type is subject to too great a heat fluctuation due to opening doors, draft changes, etc., is not well taken, as the independently fired type is influenced to as much or greater extent. It is present practice to place the superheater about midway between the furnace and the damper; that is to say, that the gases have passed over about one-half of the water-heating surface before striking the superheater. Assuming a furnace temperature of 2500 degrees, this means that the gases have fallen to a temperature between 1000 degrees and 800 degrees when they reach the superheater. Repeated observations have shown that this temperature of the gases drops about 100 degrees when the furnace door is opened for firing, and, of course, there is a greater drop in the furnace. The result is that although the heat transfer to the superheater is decreased, so also is the steam generated and the temperature of the steam shows but a small drop. The drop in steam temperature lags behind the drop in gas temperature, and the amount of drop is a function of the time the door is open. Careful firing should not give a maximum variation of over 30 per cent. of the degree of superheat at the superheater outlet. A superheater giving an average of 160 degrees would probably vary between 136 degrees and 184 degrees.

"Where a number of boilers are in battery the average superheat from all the boilers together will be very nearly constant as the fluctuations will be distributed over different boilers at different times.

"The superheater can be so designed that it will compound on overload; that is, the degree of superheat will increase with increase of load up to a certain point. One case showed an increase of superheat up to 30 per cent. overload, and then a slight decrease to 40 per cent., the curve falling off much less rapidly than it had increased.

"In large units the boiler setting superheater as now designed does not average over 175 degrees superheat, although many are sold to develop 200 degrees. In order to get the higher degrees of superheat, it is necessary to get more space within the setting by increase in the hight.

"One type of boiler places the superheater between the first and second rows of tubes directly over the furnace, but protected by tile. This design secures high superheat with minimum heating surface, but there is considerable doubt as to the life of the tubes.

"The following method of determining the ratio of superheating surface to boiler horse-power for a given degree of su-

perheat gives results very close to the actual. J. E. Bell has derived the formula:

$$\frac{1}{(T-378°)^{0.16}} = 0.172\,H + 0.294\,.$$

which is based on a saturated temperature of 378 degrees, and a furnace temperature of 2500 degrees, and in which T = the temperature of the gases at any point in the boiler, and H = the per cent. of the total heating surface between that point and the furnace. This curve gives the temperature of the gases at any point in the boiler, if we know the per cent. of heating surface passed over from the furnace to that point, and also the temperature of the gases. This curve has been checked by actual temperature readings and found to be quite accurate. After locating the position in the boiler at which the superheater is to be located, the temperature of the gases striking its tubes can be secured from the curve.

"The heat absorbed by the superheater per boiler horse-power-hour will be equal to 30 (the pounds of water per horse-power-hour) × 0.5 (the specific heat of superheated steam) × S (the superheat in degrees Fahrenheit.)

"Take 3 B.t.u. as the heat absorbed by the superheater per square feet per hour per degree difference between the temperature of the gases striking the superheater and the average temperature of the steam in the superheater.

"The heat absorbed by the superheater per square foot per hour will be 3 × the temperature difference. The average temperature of the steam in the superheater is taken as 378 degrees (the temperature of saturated steam at 175 pounds) + ½ S (the degree of superheat.)

"The square feet of superheating surface per boiler horse-power = the heat absorbed per horse-power + the heat absorbed per square foot. This formula reduces to:

$$X = \frac{10\,S}{2\,(T-378) - S}\,.$$

"This formula has been used in designing a line of superheaters and has given satisfactory results. The formula gives a basis for the design which must frequently be changed on account of local conditions which are not taken care of by the formula."

Mr. Toltz suggested the regulation of temperature by the use of dampers controlling the amount of gas flowing through the superheater.

Superheaters as at present designed transmit only from 2.5 to 3.6 British thermal units per hour per degree difference in temperature, and per square foot, while in some cases superheaters of proposed designs have transmitted as high as 11 British thermal units.

In Europe not only engines but steam turbines are designed on somewhat different lines for the use of superheated steam, the main object being to take care of the great and sudden strains due to expansion and contraction. Mr. Toltz did not favor separately fired superheaters.

He cited the results of tests made on a 5000-horse-power triple-expansion engine, under the following conditions: Pressure, 109 pounds; temperature, 381 degrees Fahrenheit; cut-off, 4 per cent.; piston speed, 16.5 feet per second (990 feet per minute); valves, 4 poppet; consumption of saturated steam per horse-power-hour, 11.82. The results follow:

Superheat.		Saving, Per Cent.	
		Steam.	Coal.
144° F	Direct	7	3.0
	Indirect	7	8.0
216° F	Direct	13	4.5
	Indirect	13	6.0
288° F	Direct	19	1.0
	Indirect	19	19.0
353° F	Direct	22	1.5
	Indirect	22	11.5

The "direct" means the separately fired; the "indirect," the combined superheated. To these figures should be added from 5 to 7 per cent. gain in the pipe line.

More prominent are the gains from superheat in a 250-horse-power compound-condensing engine: Pressure, 142; temperature saturated steam, 354 degrees Fahrenheit; cut-off, 6 per cent.; piston speed, 600 feet per minute; four piston valves; consumption saturated steam, 15.73 pounds per horse-power-hour. These results follow:

Superheat.		Saving, Per Cent.	
		Steam.	Coal.
130° F	Direct	15.0	1.5
	Indirect	15.0	11.5
202° F	Direct	20.0	4.5
	Indirect	20.0	14.0
274° F	Direct	26.0	8.5
	Indirect	26.0	17.5
338° F	Direct	28.5	9.0
	Indirect	28.5	18.5

They had had no trouble with cast-iron headers and used either cast iron or malleable iron indiscriminately for the return bends in locomotive flues. For joints they used copper gaskets; for valves, globes, never gates. A valve of the poppet type, especially the double-seated, is the best.

Professor Goss said that pressures in locomotive practice had gone too high. There are fewer compounds in use today than there were five years ago. Locomotive men are after something which will let them carry lower pressures and use simple engines without sacrifice of efficiency.

The efficiency of a locomotive boiler depends upon the rate of evaporation. With steam superheated 150 or 200 degrees, the cylinder performance may be improved 12 or 15 or 18 per cent. Then the same rate of evaporation may be maintained by leaving out 15 per cent. of the heating surface and we can use the space we have saved for superheating surface. Thus the cycle is complete.

MATERIALS FOR THE CONTROL OF SUPERHEATED STEAM

By M. W. Kellogg

As in nearly all instances in a superheated-steam station the old-fashioned screwed joint is not satisfactory, it is necessary to "work" the pipes; that is, to make a welded, "Van Stone" or other joint of that character. It is practically impossible to work wrought-iron pipe. In making a Van Stone joint the pipe is nearly sure to slit badly, not only at the weld, but all around its outer circumference. On the other hand, a good quality of wrought-iron pipe will cut and thread more easily with standard pipe machines and standard dies than a steel pipe, and a bessemer steel pipe will thread more easily than an open-hearth. Full-weight commercial pipe he believes to be perfectly suitable for any temperature and any working pressure up to 225 or 250 pounds, as long as it is not thinned at any point by cutting and threading. The design of fittings is in a general way very satisfactory with the one exception that few manufacturers in their standard articles include what is known as the "long fillet" between the body of the fitting and the flange. The latest practice is to do away with fittings entirely on high-pressure steam lines, and put in what are known as "nozzles" on the piping itself. This is accomplished by welding wrought-steel pipe on the side of another section, so as to accomplish the same result as the fitting. In this way rolled or cast-steel flanges, on a Van Stone or welded joint can be used. This has three distinct advantages, the quality of the metal used, the lightening of the entire work, and the doing away with a great many joints.

The author believes that nearly any of the designs of valves made by the good manufacturers are entirely suitable, such as a broken or solid-wedge valve of the ordinary type, provided that all machine work is done thoroughly, and that the quality of metal used is satisfactory for the purpose intended. He shows that by calculation a piece of steel six inches long, heated 500 degrees, will expand nearly 0.02 of an inch, which would have a large effect on the permanency of the tightness of a valve subjected to that variation of temperature.

German authorities state that cast iron should not be used above 480 degrees Fahrenheit. Other authorities allow as high as 575 degrees. Above these temperatures the limit of elasticity is reached with a pressure varying from 140 to 175 pounds. Under such conditions the material is strained, and does not resume its former shape. Surface cracks show and continue to grow until the metal fails. The temperature changes result in time in a shrinkage of all the parts, and to a structural alteration of the metal, which results in leakage in valves, and in the fittings. Therefore, it would seem that cast iron is unsuitable for both fittings and

valves to be used in any superheated-steam work. While they may last for some time, after a few years the metal becomes very weak and some cast iron has reached the point in weakness where if it is merely tapped lightly with a hammer, it will break into pieces. The only adaptable metal he believes to be cast steel. The influence of high temperatures on bronze, etc., is very material and seems to eliminate entirely brass or bronze of ordinary composition for use with highly superheated steam. Nickel, on the other hand, is very suitable for such use. For spindles on superheated steam work he strongly recommends nickel steel.

Seatings in valves should not only be screwed in, but also pinned, using a fine thread, which is very long to give a tight joint. Seats should have a flange on the top that makes a joint with the body when screwed down, and prevents the tendency to leak through. He also condemns the use of screwed joints, leaving for general use only the welded, and that known as the Van Stone or Climax joint. The welded joint, if thoroughly made, is very good, although for erection purposes, due to the fact that the flanges cannot swivel, it does not equal the turned-over joint for convenience in erection.

The author believes that such a joint properly made is equal to the welded joint as a manufactured article, and superior to the welded joint as an article for erection, and calls attention to some of the details which should be particularly looked after in making such a joint. He has used many forms of gaskets and has had the best results with a corrugated, soft, Swedish steel gasket with Smooth-On applied, and with a gasket which is of copper or bronze surrounding asbestos. Bad results usually follow the use of the ordinary corrugated copper gasket, which is subject to pitting. A great many troubles have occurred because of imperfect erection. If joints are pulled up entirely on one side and left loose on the other, and then taken up on that side, trouble with the gasket is almost certain. The bolts should be taken up gradually all around the flange.

J. Rowland Brown, discussing Mr. Kellogg's paper, said that there semed to be a movement in the direction of getting away from threaded joints in favor of the welded, the Van Stone and similar types. On paper the threaded joint has three chances to leak, to one in either of the other types; but while one could get pipe up to 8 and 10 inches in diameter threaded most anywhere, the other work had to be made up before shipment, and at least one length should be left to be made up in the field with screwed flanges, so as to relieve the piping of unnecessary strains due to springing the pipe into place. Many plants are using superheated steam with threaded joints in the mains successfully. The piping must be extra heavy and the joints peened or rolled with a roller expander. Most leaky joints are due to careless erection and the springing together of pipe laid out from plans and not accurately fitted for the job.

He had experimented with various kinds of gaskets and had found that the method of installing them had more to do with their success or failure than the type of gasket used. In superheaters connected for flooding, an especially hard condition is met; that of having the joint alternately subjected to superheated steam and water. He had had success with three kinds of gaskets. A gasket made of long fiber asbestos held together with an unusually small quantity of binding material, coated with graphite and subjected to heavy pressure, gave good results and withstood high temperatures. A joint made by grinding together a male-and-female flange, and then inserting a thin soft-steel corrugated gasket covered with graphite and oil, seems to meet all conditions, but must be carefully put up.

He had used a joint in which both flanges have a groove, and a cast-iron ring is ground to a seat on each of the flanges and then used as a gasket. In cases where the flanges are too large to be ground together this form of joint is especially valuable. Another advantage is that there are no male flanges which are liable to be injured in transit, or while lying around awaiting erection. The cast-iron rings should be made in standard sizes and carefully boxed. When this joint is properly assembled it will stand the conditions present in flooding a superheater without any signs of leakage. In cases where it was necessary to spring the pipe in order to make up the joint, it was found best to put a corrugated-steel gasket on each side of the cast-iron ring.

Mr. Foster did not agree with Mr. Kellogg in regard to the difference between pipe lines carrying superheated and saturated steam. A pipe line to carry superheat up to 500 degrees would not differ materially from one to carry 100-pound saturated steam. He knew of plants put in 10 or 15 years ago recently equipped for superheating without a single change in the pipe lines. There have been several instances of failures of pipe lines, but whenever he had investigated such he had found them to be due to excessive temperature.

He rather favored the use of cast iron in pipe lines. He knew of many cast-iron fittings which have been in use for 15 to 18 years and show none of the deterioration of which Mr. Kellogg tells. He knew of a pipe line which has been in use for seven years, subjected part of the time to something like 1000 degrees Fahrenheit, and although of cast iron, it is in as good condition as when built. You should get good cast iron, not porous.

Secretary Rice tried to guide the discussion toward the advantages of superheating by stating the question as, "Shall We Superheat or Shall We Not?" One of the largest manufacturers of steam-consuming apparatus had told him that there was a gain of 13 per cent. to be had from superheat, but that it took 12 per cent. more fuel to make it.

Mr. Kruesi, of the General Electric Company, said that a combined superheater would take as much fuel as would make a boiler without a superheater develop an amount of power equal to that obtainable from the superheat. There is no saving with superheated steam unless it is with the steam turbine. Two tests made about a year and a half ago showed 14.7 per cent. more fuel used under the boiler with the superheater.

His own practice concerning the use of superheat with turbines is to use:

75° superheat at boiler, up to 2000 kilowatts.

100° superheat at boiler, up to 3000 kilowatts.

125° superheat at boiler, for the 5000- and 8000-kilowatt units.

This is as high a temperature as can be handled to advantage with the materials available at present.

In support of Mr. Bolton's statement as to the variation of superheat, he offered the following results from a battery of eight boilers:

Max.	*Min.*	*Ave.*	*Difference*
176	106	140	70
110	33	79	77
138	57	87	81

A fireman who could not keep his steam pressure constant within 25 pounds would not be worth keeping, but 25 pounds variation in the pressure would mean only about 10 degrees variation in the temperature. The above results were produced, by the best firemen they were able to procure. With such variations in temperature, troubles with joints, gaskets, valves, etc., are easily accounted for. Gate valves should not be used for superheated steam; globe and angle valves are better. The gate valve is satisfactory in ordinary practice only when used in the vertical position for which it is designed. He condemned the use of cast-iron fittings in pipe lines, and declared that he could show tons of such fittings, extra heavy, and believed to be the best procurable, all scrapped in less than a year of operation. He would go farther than Mr. Kellogg and state unequivocally that cast steel is the only suitable material for fittings, even for saturated steam of 150 pounds or over.

EXPERIENCES WITH SUPERHEATED STEAM

By George H. Barrus, M. E.

This paper recounts experiments made by the author in this connection, commencing with the "Dixwell" experiments made at the Massachusetts Institute of Technology, in 1874, to show that the degree of superheating necessary to prevent cylinder condensation varies in direct proportion to the ratio of expansion. The steam was superheated by carrying the

water-line low in a vertical tubular boiler, and it was found that a temperature as high as 600 degrees Fahrenheit could be maintained without difficulty while superheating all the steam that an 8x24 non-condensing Corliss engine could use, the diameter of the boiler being 36 inches. A pyrometer was used inside of the cylinder to indicate the variations of temperature, and it was found that with a ratio of expansion of 3 to 2 (that is, where the volume after expansion was 1½ times that at cut-off), the number of degrees of superheat required to prevent cylinder condensation, as indicated by fluctuation in the indications of the pyrometer, was about 110 degrees. With the ratio of 2½ to 1 the number was increased to 146 degrees, and with a ratio of 4 to 1 it was increased to 190 degrees. When the engine was running with ordinary saturated steam the pyrometer responded to the variations of temperature in the cylinder, and during every revolution the index hand vibrated over a range of 20 to 25 degrees. When the steam was superheated to a sufficient degree the vibrations disappeared altogether, and the pyrometer indicated a constant temperature, slightly above the normal for the initial pressure.

In another experience with an independently fired superheater of the Bulkley type, it was found that one pound of anthracite coal containing 15 per cent. of ash and refuse superheated 50 pounds of steam 228 degrees, besides evaporating the moisture due to condensation in the steam pipes and whatever moisture came over from the boiler. The pressure was 75 pounds. In another case a superheater of the Bulkley type was attached to a horizontal return-tubular boiler connected with a four-valve non-condensing engine. A test made before the installation of the superheater showed a consumption of 4.4 pounds of anthracite coal per indicated horse-power-hour. With the superheater in use this was reduced to 4.1 pounds, but the superheat was only 66 degrees, and not sufficient to entirely overcome cylinder condensation. An additional grate was arranged below the superheater, and the superheat raised to 165 degrees, under which circumstances a test with the superheater shut off showed a consumption of 4.21 pounds, and with the superheater running 404 pounds. The decrease in evaporation per pound of coal due to the superheater was 10.2 per cent.

In the case of four simple engines which the author tested when the amount of superheating ranged from 25 to 59 degrees, with an average of 34 degrees, there was a reduction in the percentage due to the condensation and leakage, as compared with that found in engines using ordinary steam under similar circumstances, amounting to 8 per cent. In another case steam superheated 75 degrees dropped in temperature 49 degrees in passing through a 12-inch pipe 270 feet in length. In another case with a separately fired superheater, it was found that one pound of dry coal superheated 29 pounds of steam 337 degrees, besides evaporating the moisture.

A noteworthy feature of this test was the effect of the highly-heated steam on the joints of the piping, and on the packing and gaskets of the valves. Whenever the steam came in contact with the fibrous material or rubber, these were completely burned out and the joints or valve caps set to profuse leaking. The flange joints in the piping, which were of the Van Stone type, with corrugated copper gaskets, were injured to some extent, and many of them set to leaking. The plant had previously been run at a temperature not over 500 degrees. Under this temperature there was no leaking at any point.

In another case one pound of dry coal superheated 49 pounds of steam 303 degrees, besides evaporating moisture in the steam supplied by the boiler, estimated at 1 per cent. The Corliss compound-condensing engine, to which the steam from this superheater was supplied, was found to consume 9.8 pounds of steam per indicated horse-power-hour, but the superheating at the throttle was 300 degrees. In another case, making allowance for the heat represented by the superheating on the assumption that the specific heat is 0.48, the efficiency of the two outfits came out precisely the same, namely, 75 per cent. of the calorific value of the fuel.

Mr. Kruesi said that, roughly, the steam consumption of a turbine will be reduced 1 per cent. for each 12 degrees of superheat. With superheat as high as 250 degrees, the steam consumption will be reduced 1 per cent. for about 10 degrees, while with 75 degrees of superheat it will take 14 or 15 degrees to affect the consumption 1 per cent. The boiler makers have been very backward in giving estimates of the amount of coal required for a given degree of superheating. He had said that 250 degrees of superheat in a combined superheating boiler operating a turbine showed no plant economy. He did not mean by this that superheating was not desirable. On the contrary, he considered it very desirable.

Mr. Foster pointed out that Mr. Barrus cited a pipe line where no trouble was found with joints at 550 degrees, whereas at 697 degrees they had a great deal of leakage at the joints. He could corroborate that from his own experience. Frequently a pipe line will leak with saturated steam, but will not leak with superheated steam. He accounted for this by assuming that in the case of the superheated steam the temperature was the same at the top and bottom of the steam line, while in the case of the saturated steam there would be condensation running along the bottom of the pipe and keeping it cooler than the top. He had noticed that a pipe line, unless under a great external strain, will leak at the bottom of the joints. In answer to Mr. Kruesi's statement that there is no ultimate economy from the use of superheat in small plants he had had an opportunity to observe the saving effected in plants of 100 to 200 horse-power, and it had been remarkable, in some cases more than could be accounted for theoretically. He had rarely had a report where the saving was less than 10 per cent., and frequent authentic reports of 20 to 25 per cent., with superheat of 150 to 200 and moderate pressures.

Mr. Toltz knew of Mr. Foster's work and his tests check up within 1 or 2 per cent. He knew of one particularly at the Brooklyn water works, where with 225 degrees of superheat they have a saving of 23 per cent. on steam and 21 on coal. Mr. Kruesi must design his turbines for higher superheat.

USE OF SUPERHEATED STEAM IN AN INJECTOR

By Strickland L. Kneass

It is obvious that any condition which tends to diminish rapid condensation operates against efficient mechanical action of an injector. An increase in the temperature of the water supply, moisture or superheat in the steam all tend to reduce the proper ratio between the weight of the water delivered into the boiler to that of the motive steam.

Results of experiments with saturated steam prove that the flow is in accord with the well known formula based on adiabatic expansion. The velocity of superheated steam is slightly higher as it follows the law of a perfect gas until condensation due to expansion commences. The velocity of the combined mass would consequently be increased, but this advantage is overbalanced by the shorter interval of contact and condensation during which the additional heat in the steam must be abstracted. The mechanical efficiency is lowered. If there is no loss from radiation the thermo efficiency will still be 100 per cent. To obtain good results from an injector with superheated steam it would be necessary to modify the design and proportion of the tubes and nozzles.

The practical effect of superheated steam upon the action of an injector is to reduce the maximum capacity, increase the minimum capacity, and to lower the limiting temperature of the water supply with which the condenser can operate. Further, with high pressure and superheat an inefficiently designed instrument is inoperative. It is therefore advantageous and usually practicable to have a special pipe to supply the injector with saturated steam.

This paper evoked no discussion.

Still other papers upon superheaters were submitted and discussed, but they related to locomotive practice and brought out little of interest to the general subject.

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Superheated Steam

It is well that the American Society of Mechanical Engineers has directed the attention of its research committee to the subject of superheated steam. The recent symposium at Indianapolis added to the current knowledge of the subject the record of an exhaustive series of determinations of the specific heat, at variance with the records of other observers who do not, however, agree any too well among themselves; opinions that common pipe mains with cast-iron fittings are plenty good enough, and opinions that they are no earthly good; opinions that the separately fired superheater is the real thing, and opinions that the combined superheater is the only thing to use; opinions that gate valves are very satisfactory, and opinions that gate valves should on no account be used; opinions that the fluctuations in temperature in ordinary practice are wide and destructive, and opinions that they are insignificant and negligible; opinions backed up by tests to show that the ultimate fuel saving was not over 1 or 2 per cent., if it was anything, and opinions backed up by tests equally as reliable that savings of between 20 and 30 per cent. are feasible and easily obtained.

It is time that a systematic investigation was made by disinterested authorities thoroughly equipped with means and experience to determine not only the physical properties of saturated steam, but the advantages and disadvantages attending its use, and under what conditions it can be used at a profit.

Unwarranted Discrimination

John C. Black, president of the United States Civil Service Commission, has overstepped the bounds of reason and propriety, if not of law, in specifying that no applicant shall be eligible to take the civil service examination for the position of chief engineer in the United States Post Office and Court House Building at Chicago unless he is a graduate of a technical institution or engineering college. We understand that Mr. Black is supported in this position by the Hon. George B. Cortelyou, Secretary of the Treasury.

May we be permitted to respectfully represent to the Honorable Secretary of the Treasury that it is none of his distinguished business where the applicant for a position gets his knowledge or experience, so long as he has the necessary qualifications and can prove it. It is quite possible that the position in question, paying the munificent salary of eighteen hundred (not thousand) dollars per year, with an attainable maximum of twenty-five hundred (not thousand), may call for exceptional qualifications. It is quite within the province of the commission to require that the applicant shall be versed in thermodynamics, and the use of the integral calculus, but if a man has all the qualifications that they specify, all the practical experience that they require, if he can answer satisfactorily a sufficient percentage of the questions which they propound, what earthly concern is it of theirs whether his father bought his knowledge for him from a technical school, or whether by energy and application he dug it out of the solid rock in the intervals of his daily toil, or bending over the kitchen table when the "tech" boys were making night hideous with cane rushes and other improving pursuits?

The President of the United States is in complete control of the practice of the Civil Service Commission. He has never made nor sanctioned such a discrimination against the self-educated man; a discrimination which would have disqualified John Fritz as an engineer, Thomas A. Edison as an electrician, Sydney Gilchrist Thomas as a metallurgist, the author of the "Footprints of the Creator" as a geologist, and the better half of the exponents of applied science in the industrial world today.

Let the examiners find out what each applicant is, not how he became so. Let there be no discrimination, not even in favor of the self-made man as against the graduate.

Think it over, Mr. Secretary.

Give us a square deal, Mr. President.

The Temperature of Steam Pipes

In discussing the troubles to which steam mains are prone under the action of superheated steam, at the Indianapolis meeting of the American Society of Mechanical Engineers, Ernest H. Foster remarked that joints which leaked profusely under saturated steam frequently tightened up when the steam was superheated, and ventured the explanation that in the latter case the temperature of the pipe is the same all the way around, while in the case of the saturated steam there is always a rill of water running along the bottom of the pipe and keeping it cooler than the top.

The question naturally arises how this water, resulting from the condensation of the steam or brought over from the boiler with it, running along in intimate contact with it, and in contact with a pipe heated by the contained steam, can get much below the steam temperature. It is a common experience, however, that where water is pocketed the top of the water may be at the temperature of the steam above it and that at the bottom stone cold. The more nearly the conditions of the main approach those of the pocket, the cooler may the water become, and it is quite possible in lines of small pitch, and where vertical globe valves, etc., present obstruc-

tions resulting in pockets, that there may be considerable difference between the bottom and the top of the main.

But now come Berner and Jacobus and others with the assertion that the rill exists just the same with superheated steam; and Hosea Webster conceives that the superheated steam is carried in the form of a core surrounded by an annulus of cooler steam against the pipe, and doubts if the temperature of the metal of a pipe conveying superheated steam exceeds much, if any, the temperature due to the pressure. If water exists here in any considerable amount it would produce a greater difference in the temperature, top and bottom, of the main than could exist with saturated steam, but the assumption is that water in superheated mains is a phenomenon not so frequently observable nor in nearly such amounts as obtains in the case of saturated steam.

Steam versus Gas Power

In the discussion, at the recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, of the comparative merits of steam and gas engines when heating is to be done, the author of the table on page 459 credits the steam engine with 80 per cent. of the heat furnished to it and makes the power cost 66 per cent. as much, when all the steam is used for heating as when all the steam is charged to the power. This is done because none of the standing charges are transferred to the heating account, that account being charged only with 80 per cent. of the purely operating expenses. It would seem, however, that in order to get a just comparison of the relative merits of the two systems, the costs both of installation and operation of a steam plant running condensing in summer and non-condensing during the heating months should be correlated with the costs of installation and maintenance of a gas-power plant and an auxiliary heating plant. The heat rejected by the gas engine would help do the heating, of course, so that the heating plant would not need to be large enough to do it all.

A comparison made in this way might put quite a different face upon the matter from that established by the table in question, where the only case in which the steam plant has the advantage over the gas plant is at half load and with the shorter daily run, when the gas engine is most heavily handicapped by the standing charges, and when all the exhaust is condensed for heating. There are some other features of the table which seem also to need amendment. The first costs of all the gas plants are certainly put high enough to afford attractive profit, while the cost of the 200-horse-power steam plant is pretty low. The heat value accredited to bituminous coal is well below the average, while that assumed for anthracite is well up. We should be inclined to transpose the figures, or at least consider bituminous coal equal to anthracite in heat value. These defects in Mr. Findlay's basic data naturally weaken his comparison.

Too Deep

In our last issue we published a test from a facetious contributor showing a grossly impossible gain by burning ashes. The writer is a mechanical engineer of national reputation, and the results of the test were presented with all the formalities of the professional code; but aside from the ridiculousness of the results we thought that the facts that the report was dated April 1, was made for the "Nonesuch" Button Works of "Balsac," and was signed by "Ananias Guessitt" would mark it as a clever skit upon the current fallacy. It proved too deep, however, for one of our readers, who addressed a serious inquiry to Doctor Stillman, professor of chemistry at Stevens Institute, asking how he reconciled his statement in the same issue, that the burning of ashes was a chemical absurdity, with the results obtained by Mr. Guessitt. The ash-burning excitement has about blown over and an Altoona (Penn.) paper anounces that "the cobbler may go back to his last."

Dubious Information as to Gas Producers and Engines

At the Washington meeting of the National Electric Light Association some interesting statements were made in a paper read by R. T. Lozier. Here are a few of them:

"It may be interesting to state at this point that the rating of a gas engine is determined by the ability of the crank-shaft to carry the load. The fact that one gas engine has bigger cylinder dimensions than another, both having the same-sized crank-shaft, simply indicates that the engine having the larger cylinders is designed to consume more B.t.u per horse-power than the other."

"The limitation of compression is not determined by the strains that the *cylinder* can stand."

"The question has often arisen as to why engines that have operated successfully on natural gas and illuminating gas have failed on producer gas, and the writer has it on the authority of a skilful gas-engine designer that it is because the producer gas has not the marsh and olefiant gases to tone off the snappy sensitive and quick-firing properties of hydrogen."

"The rate at which the gas is made is a function of the heat of the producer; that is, the more gas made, the hotter the fire tends to be. As we all know, passing steam over an incandescent fuel bed decomposes it into hydrogen gas."

"We will assume that the steam plant will deliver its current to the center of distribution at the rate of three pounds of coal per kilowatt, while the gas plant will deliver its current at the rate of one and one-half pounds of coal per kilowatt-hour to the same section."

The author did make a fairly intelligent suggestion as to the use of gas-power sub-stations by large central stations for taking part of the load during periods when the specific cost of operation is equal to or less than that at the main station; but for the most part the paper was calculated to drive the gas producer and engine to beg deliverance from their "friends."

Gas Power in South Africa

We have reports from South Africa *via* London that are not altogether favorable to the installation of gas power for driving the electric tramways of Johannesburg. In fact, one report is to the effect that the gas producers have signally failed and that the tramways are not running, but that great urgency is being pressed upon steam-engine makers in Great Britain to make good the deficiency. This, if all true—we have yet to hear the other side—will do harm to the gas engine and to the gas producer; but in no case should it be allowed too much weight, for we are also informed that a well-known gas-power expert, now in London, expressed an opinion that was by no means too favorable when he learned the kind of plant that was to be adopted in Johannesburg.

Much dissatisfaction has been expressed generally over this whole business. Months ago there were rumors that there was trouble with the plant. These rumors were contradicted, yet they never appear to have been laid.

The coal used at Johannesburg is bituminous, and, as is well known, this coal is difficult to work in a producer. There is a tendency for it to hang up in the producer, in which case so-called straight air may get through the fuel bed uncombined with carbon and may produce a dangerous mixture beyond, which may ignite with destructive effects. Something of this sort may have occurred at Johannesburg, an explosion of the producer being mentioned.

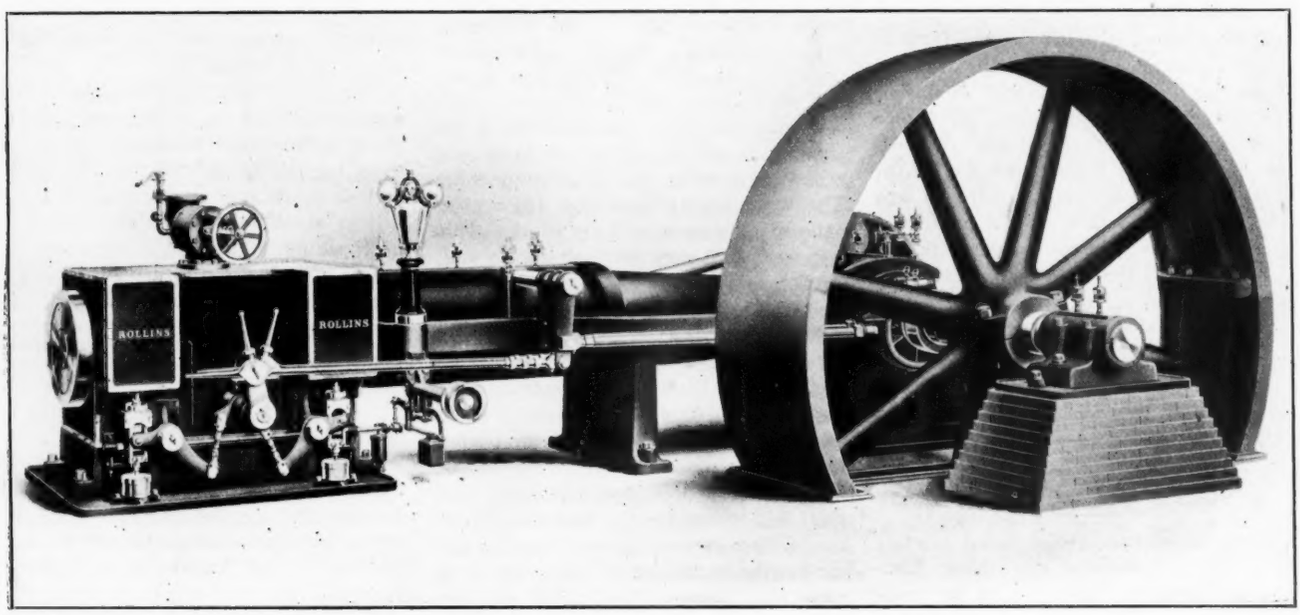
There is and always has been a tendency to build gas producers much too shallow. Many are both shallow and square, and the fuel does not so readily fall as it should; and it is quite common knowledge that in a shallow producer the carbonic-oxide gas burns at the top of the fuel bed by means of the oxygen that gets too freely through the empty corners of a producer.

The Remodeled Rollins Engine

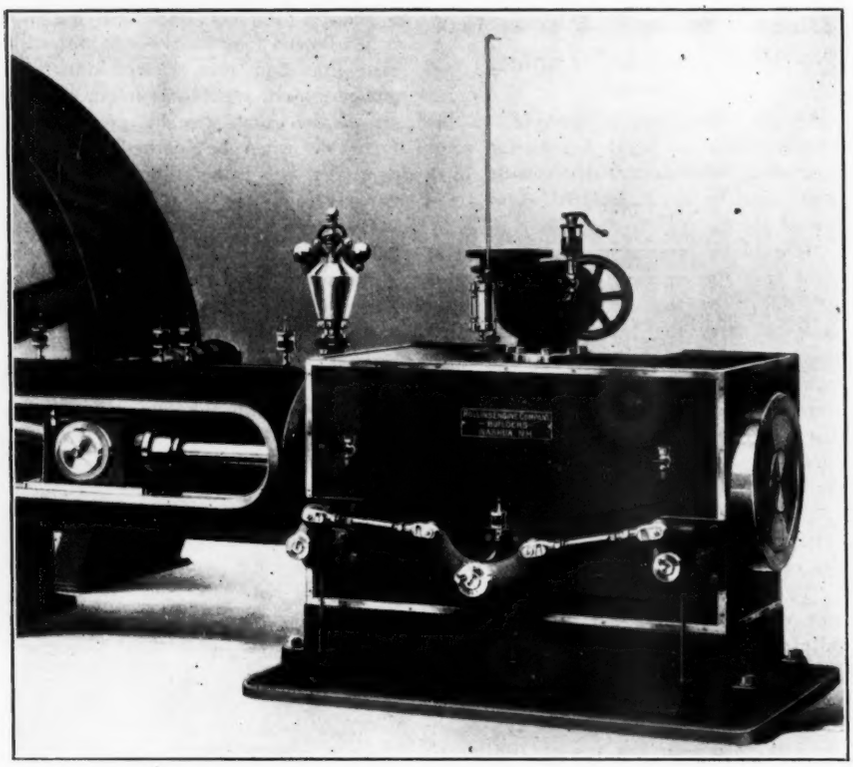
The "Model No. 2" Rollins engine, built by the Rollins Engine Company, of Nashua, N. H., is the latest development by this company. It embodies some interesting details, among which may be noted a high-speed governor which also combines a safety stop, improved valve-gear in connection with double eccentrics, and accessibility of the parts. All moving parts are made as light as possible consistent with safety and strength, and the design embraces the well-known combination of grid-iron steam valves with double-ported semi-balanced exhaust valves.

As the accompanying illustrations show, the frames are massive in design; there is a heavy web on the back, and a broad support under the center extending across the full width of the frame is bolted to the foundation at both front and back. The crosshead guides are bored, and attention is directed to the wide bearing surface.

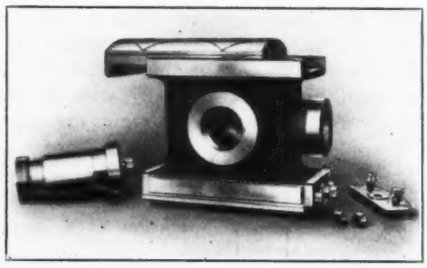
The cylinders are made of hard, close-grained iron. The steam passages are short and direct and the port areas are ample. The exhaust passages are separate from the cylinder walls, to avoid undue condensation. The base extends the full length of the cylinder and is cast integral with the foundation plate. The cylinders are drilled and piped for indicator connections.



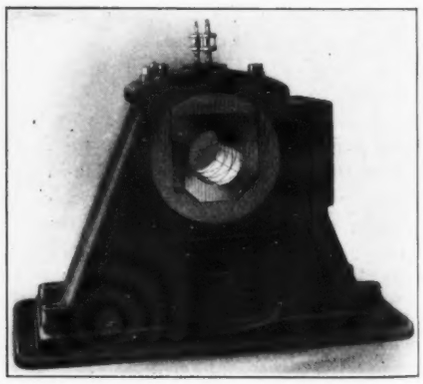
VIEW OF ROLLINS ENGINE ON ADMISSION VALVE-GEAR SIDE



SHOWING EXHAUST-VALVE WRIST-PLATE AND LINKAGE



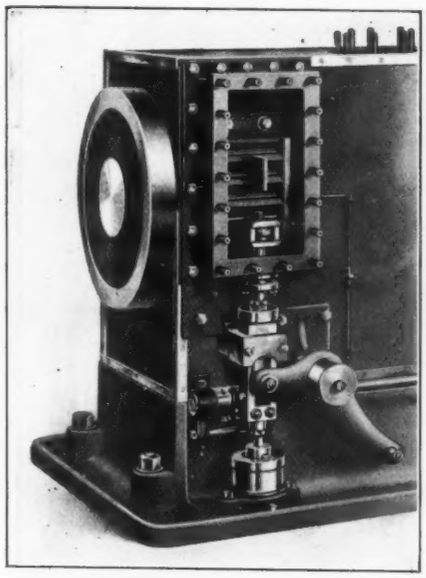
THE CROSSHEAD



THE PILLOW BLOCK

The design of the pillow block is interesting. Reference to the illustration will show that the bracing effect of the walls extends to the top, and that the base has an unusually broad bearing on the heavy

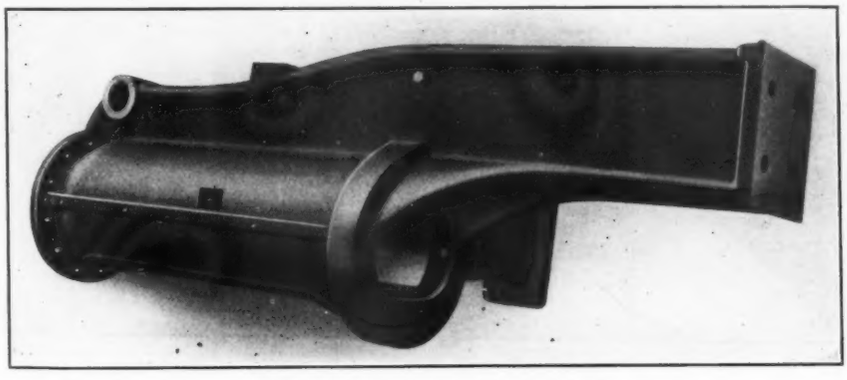
foundation. The shell boxes are in four parts, babbitt lined, bored and scraped to fit the shaft, with wedge adjustment for the side shells. The boxes can be removed by jacking up the shaft enough to



SHOWING STEAM-CHEST COVER REMOVED

relieve the weight from the bottom shell, which can then be withdrawn. The outboard bearing is in the form of a two-part box, mounted upon a heavy foundation plate, with screw adjustment.

In the Rollins piston the broad junk-ring has a bearing upon the cylinder the full thickness of the piston and is unaffected by any adjustment of the spider within the ring. Snap packing rings are used and the pistons are made with either one or two rings, as desired. The piston-rods are of high carbon steel and of extra large diameter. They are secured in the piston by taper fit, forced in by hydraulic pressure. The crosshead end is screwed into the crosshead and tightened with a heavy forged-steel check-nut; the connecting-rods are of forged steel with solid ends, the crank-pin boxes are of



DETAIL OF FRAME CONSTRUCTION

semi-steel bronze, babbitt lined, and the crosshead boxes are of phosphor bronze. Both boxes have the usual Rollins wedge adjustment.

The crossheads are of the hollow-box pattern, with large babbitt-faced shoes, adjusted by means of concealed wedges operated by screws. The shoes can be removed without taking the crosshead out of the slides or disconnecting the rods. The crosshead pins are central with the shoes, and receive the angular thrust of the connecting-rod directly over the center. The guides are bored to permit the crosshead to roll, if the foundation should settle. The pins are made of high carbon steel and have taper fits.

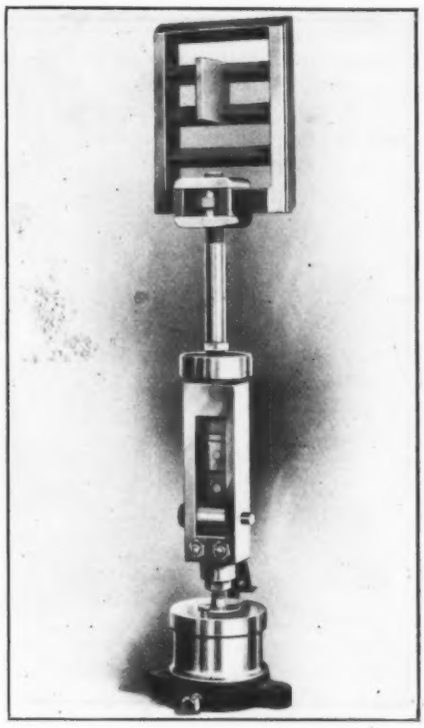
The Rollins governor is of the high-speed counterweighted type, with but few moving parts, and is said to be extremely sensitive. The safety stop is automatic.

All of the "Model No. 2" engines are built with double eccentrics and the "Rollins '91 valve gear," with a range of cut-off, controlled by the governor, varying from 0 to ¾ stroke. The inlet valves are on one side of the cylinder and the exhaust valves on the other. The wrist-plate for the inlet valves works on the exhaust-valve rock-shaft, as shown.

The admission valves are of the flat, multiported type, working upon flat seats of very hard iron. They require but small amount of travel, and close by gravity aided by the steam pressure upon the unbalanced area of the valve stem, thus dispensing with vacuum pots. The steam chests containing the valves and seats are separate castings from the cylinder proper and are bolted thereto. This permits the easy removal of the valve seats for refacing. Both valves and seats are milled out, and as they are in a vertical position they drain readily and are not liable to become pitted. Removal of the front cover plate of the steam chest gives immediate access to the valve and seat.

The exhaust valves are of the double-ported rocking type, entirely free from springs, pressure bars, etc. The steam passages are short and the ports so located as to partly balance the valves, thereby reducing friction, and as the direction of wear is directly downward, the steam fit of the valves upon the seats is not affected. Both steam and exhaust valves are located with a view to reducing the clearance to the lowest practical limit.

The crank-shafts are made of open-hearth steel or iron forgings, as conditions require, with long tapers for change of diameter. They are forced into counterbalanced disk cranks by hydraulic pressure and keyed.



STEAM VALVE COMPLETE, WITH STEM, LINK AND DASH-POT

All fly-wheels up to 16 feet diameter are made in two pieces, bolted with Norway iron bolts. Wide belt-wheels are made with double arms by bolting two wheels together at the rims. The arms are of oval section. In balance wheels the rim joints are further strengthened by shrinking in arrowhead links of Norway iron.

The Muenzel Gas Engine

Fig. 1 herewith shows the four-stroke-cycle horizontal single-acting gas engine, designed by Max Münzel, of Braunschweig, Germany, and manufactured in America by the Minneapolis Steel and Machinery Company, Minneapolis, Minn.

The Münzel gas engine is built either right- or left-hand. The outer cylinder barrel is cast in one piece with the heavy frame, and the frame extends nearly to the back of the cylinder, a design calculated to conduct strains directly to the foundation and at the same time obviate, to a great extent, overhanging parts. Besides the two main bearings on the frame, which are provided with removable cast-iron shells lined with anti-friction metal, there is provided an outboard bearing which supports the end of the crank-shaft.

The space between the sides of the frame is inclosed at the bottom, forming a receptacle to catch oil drippings, while a

raised lip extends entirely around the base of the frame to prevent oil reaching the foundation.

The cylinder is lined with a plain, close-grained iron tube, flanged and secured at one end only, so that it is free to expand longitudinally. The piston and piston packing rings are of special close-grained iron and the piston is of the long trunk type.

rocker arm and push-rod. The valve and valve cage can be removed by taking out four cap-screws. The exhaust valve, which is similarly operated, is located in a vertical line below the inlet valve. A third valve, at the left-hand side of the cylinder-head, is provided to close off the chamber through which compressed air is admitted to start the engine, so as to avoid having a pocket there during normal operation. The air necessary for the explosive mixture is admitted through a number of small holes in the engine bed. The cylinder-head is water-jacketed throughout.

The crank-shaft is of the center-crank type, and is a soljd forging of mild steel, with cranks slotted and finished from the solid. The crank, crank-pin and reciprocating parts are, of course, counter-weighted. The connecting-rod is of open-hearth forged steel. The piston-pin end is provided with bronze boxes. The crank-end is of the marine type, fitted with cast-iron shells lined with anti-friction metal.

The valve-gear shaft is driven from the main shaft by spiral cut gears incased in a hood which serves as an oil well; one of the gears runs in an oil bath. The inlet

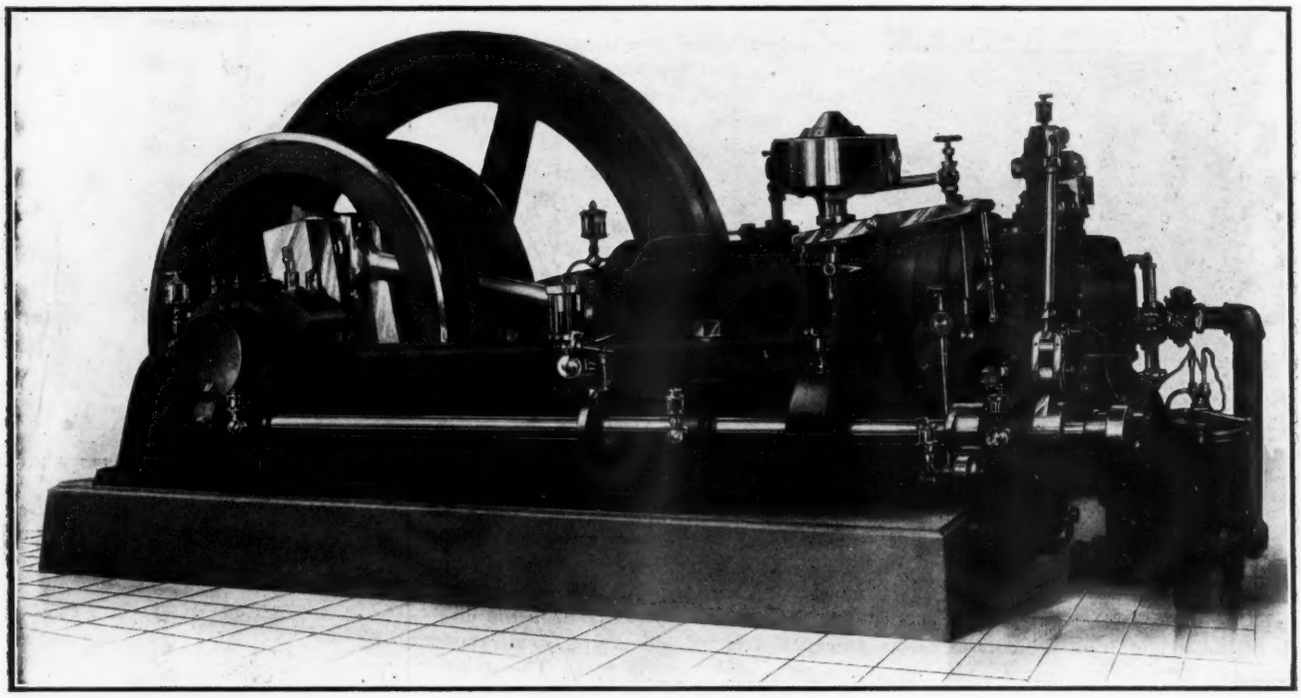


FIG. 1. MUENZEL FOUR-STROKE CYCLE, HORIZONTAL, SINGLE-ACTING GAS ENGINE

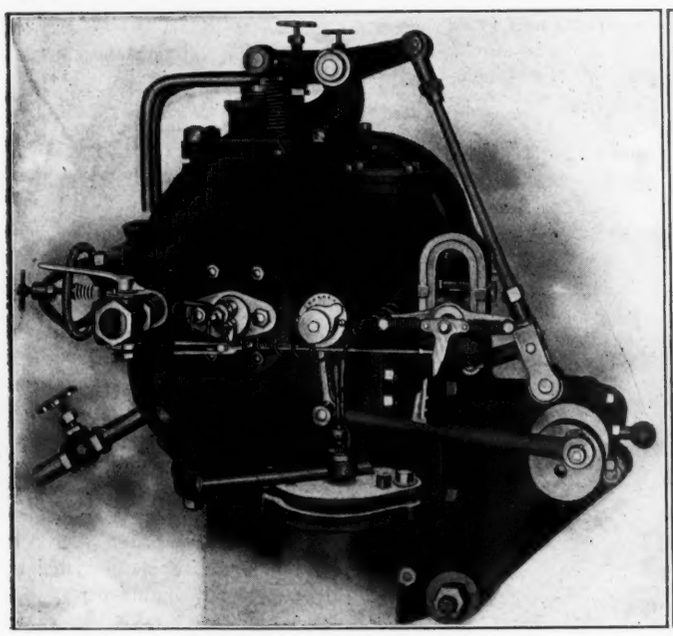


FIG. 2. CYLINDER-HEAD OF MUENZEL ENGINE

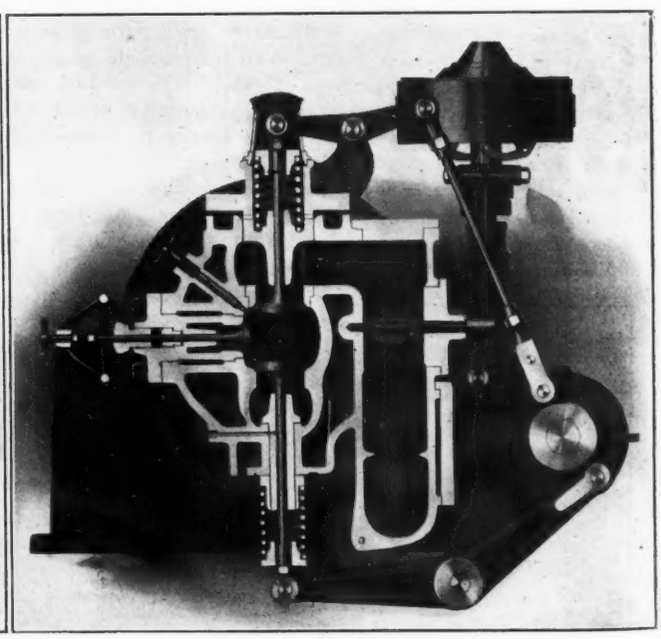


FIG. 3. SECTIONAL VIEW OF CYLINDER-HEAD

and exhaust valves are opened by tempered tool-steel cams and closed by spiral springs, as usual. The valve-gear shaft has a small crank-pin on its extreme rear end, which gives motion to a lever that oscillates the igniter trigger. The shaft runs in three boxes provided with bronze bushings.

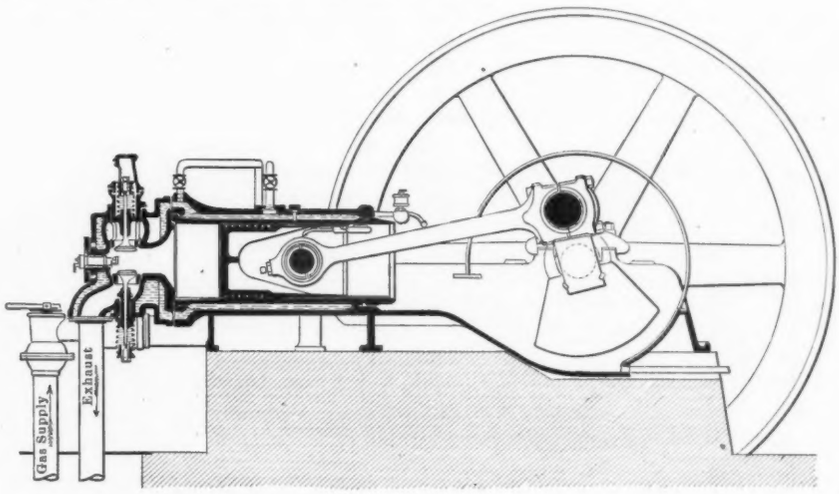


FIG. 4. SECTIONAL ELEVATION OF MUENZEL GAS ENGINE

Ignition current is supplied by a magneto having an oscillating armature and heavy hardened-steel permanent magnets. The contact points are carried through a removable plug into the compression chamber, and the mechanism which oscillates the magneto armature also rocks the movable electrode of the igniter plug and produces the spark. The time of ignition can be adjusted by means of a hand-wheel while the engine is running.

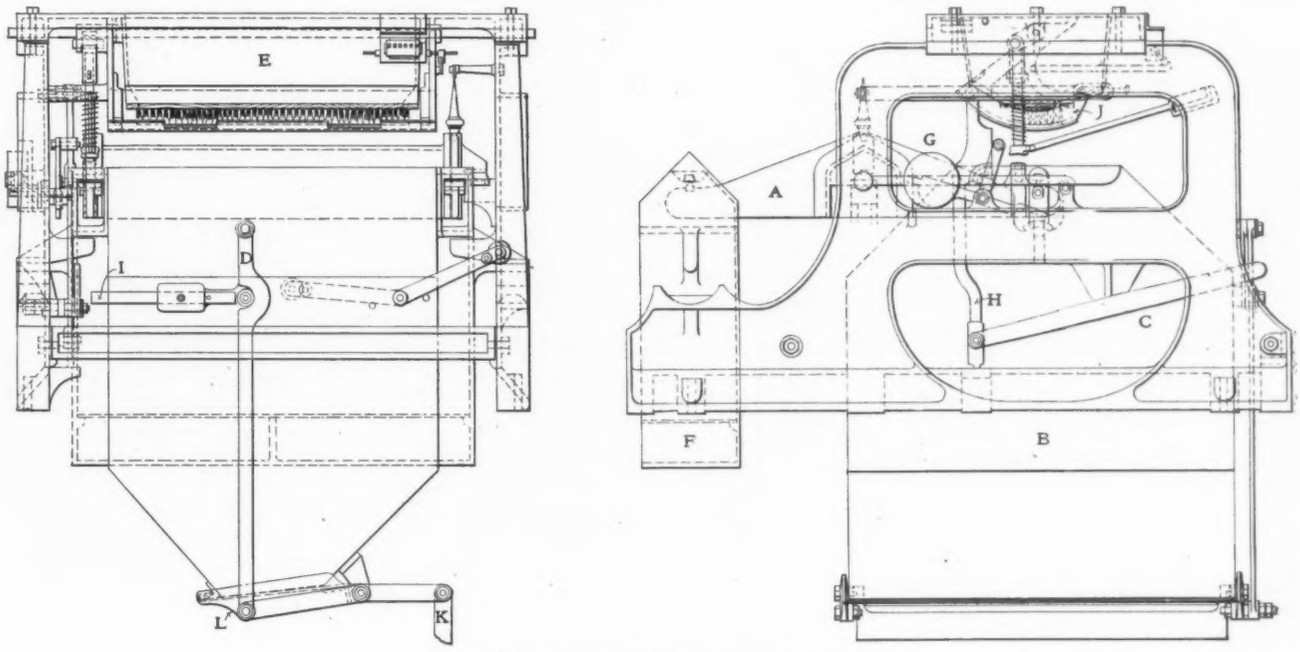
The mixture of air and gas is controlled by a valve adjusted by hand, amount of mixture admitted being controlled by a butterfly valve placed close to the main admission valve and operated by the governor. A sensitive fly-ball governor is used, in which the centrifugal force of two weights is opposed by a spiral spring.

The engine is equipped with two safety devices. One is designed to prevent the unintentional ignition of any explosive mixture that may be left in the cylinder; it consists of an electric contact arrangement connected to the gas valve in such manner that the electric circuit leading to the igniter is opened the moment the gas valve is closed. The other device automatically closes the air-supply pipe at a point close to the mixing chamber whenever the engine stops, to prevent accidental escape of gas into the bed of the engine after the engine is stopped.

The cylinder is oiled by means of a small oil pump driven from the secondary shaft, a sight-feed glass being provided in the oil line for observing the rate of feeding. The oil for the crank-pin boxes is automatically fed into a ring cup surrounding the shaft and fastened to the crank arm, whence it is carried by centrifugal force through the oil pipe to the crank-pin. The piston-pin is oiled by means of a wiper cup and stationary sight-feed oil cup located at the front end of the cylinder. All other journals are provided with stationary sight-feed oil cups, except the main bearings, which are fed by oil rings dipping into reservoirs underneath the bearings.

The Avery Automatic Scale

The accompanying illustration shows in outline an end view and a side view of the Avery automatic scale, such as is built for power-plant use, for keeping a record of the coal consumed by weighing and registering it. The scale is built on the principle of the equal-arm beam, with a weight box at one end of the beam and the weigh-hopper at the other; when both are empty, one exactly balances the other. The scale is arranged so that, when once started, it will continue automatically to weigh, record, and discharge all the material supplied to it without the assistance of an attendant, or any external power. When the material runs freely, the power necessary to open and close the gates, etc., is supplied by the gravity of the material itself. The scale may be arranged to stop working and start again automatically to conform to the speed with which the material being weighed is removed after being discharged by the scale.



END AND SIDE VIEWS OF AVERY AUTOMATIC SCALE

The operation of the Avery scale is as follows: The coal to be weighed is delivered by a suitable spout to the chute *E*

of the scale. The gate *J* is, say, in its up or open position, and allows the coal to pass into the weigh-hopper *B* until about 75 per cent. of the required weight has entered the hopper. The beam then moves down through a small arc and in doing so allows the gate *J* to close partially. The coal continues to flow into the hopper, but in a much finer or more restricted stream called the "dribble," which can be shut off with much greater accuracy than the main flow.

When coal to the exact equivalent of the weights in the weight box has passed through the gate *J*, the beam moves down farther and in doing so trips a trigger which completely closes the gate with a snap. The same movement causes the outward end of the knock-off lever *C* to move up and hit the striking rod *I* which opens the door *L* of the weigh-hopper and discharges the coal it contains.

As soon as the hopper *B* is empty the door weight *K* closes the door *L*, which brings down the striking rod *I* so that it hits the knock-off lever *C*, which actuates the drop bar *H* and allows the gate *J* in the chute *E* to be opened by the hopper end of the beam *A* moving up, owing to the now empty hopper being unable to balance the weights in the weight-box *F*. The machine is now in the condition in which it started, and the same cycle of operations is repeated as long as the chute is kept full of coal. Each weighing is registered by a counter fixed on the machine.

The function of the compensating weight *G* is to compensate for the weight of material which is in suspension when the gate is closed. This material has left the chute, but has not reached the hopper, and unless compensated for would cause an error.

If fed from a bin by a spout, no overhead hopper room is necessary, but the material should fall into the scale perpendicularly, and, if possible, sufficient hopper room should be allowed below the scale for a full discharge of the weigh-hopper.

The beam *A* is cast in a single piece in all but the largest sizes; in these, the two arms are bolted to a single heavy stretcher. The knife edges on the beam are fixed, but the steel bearings in the side frames are loose, in order to allow them to aline themselves and reduce the friction. The weigh-hopper and the weight box hang entirely free without guides or stay-rods. Possible shock, when the weight box falls back on to its stops when the hopper is discharged, is taken up by spring buffers. The scale is made of metal throughout, and except in the largest sizes all the parts are interchangeable.

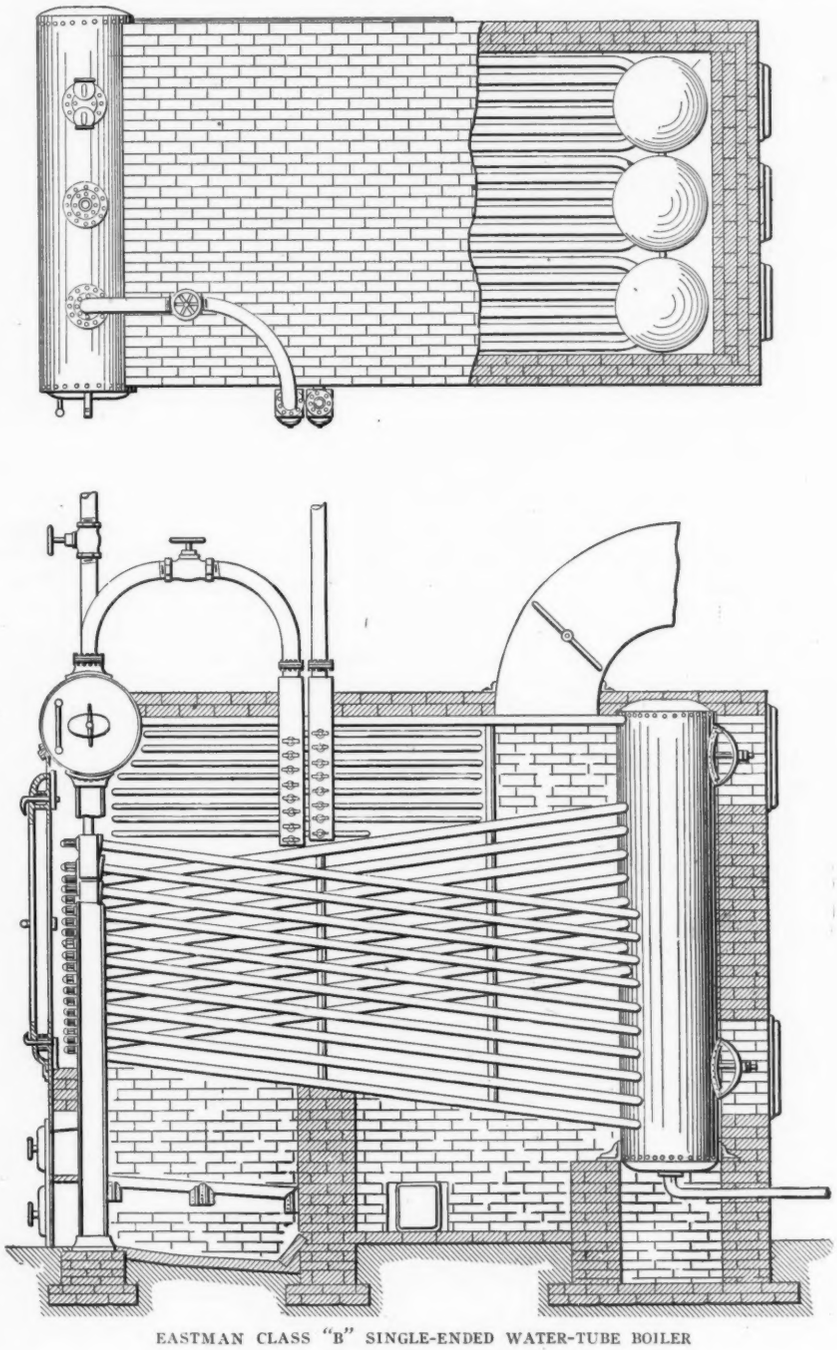
The Avery automatic scale is made either semi-automatic or entirely automatic. In the former type the weighing is performed automatically, but the material weighed is discharged from the weigh-hopper by means of a hand lever. In the latter, the machine weighs and discharges automatically as long as it is fed with material.

The larger sizes may be used for checking the coal received from the railroad, boat or conveyer. The smallest size, with a hopper capacity of 100 pounds of slack per discharge, is the one usually employed for checking the consumption of boilers. It can be fitted with a stop gear which prevents the hopper from discharging until required. It can also be arranged to adjust itself automatically to a varying feed. The machine can be fixed to feed only one boiler, or mounted on a traveling carriage so that one machine may feed several boilers.

There is also an Avery patent automatic track scale for use in power houses where coal is transported on tracks or in trucks. This scale automatically indicates the net weight of every car or truck load, adds up or registers the total net weight of all loads and counts the number of loads.

One size has been especially designed for places where the coal is in large-sized pieces, or where large pieces are mixed in with the small. It will weigh pieces up to 12-inches cube. It is also intended for very large quantities necessitating more than 3000 pounds at a discharge. The gates in these machines are electrically controlled and the scale is built on the steelyard and lever principle, permitting proportional weights to be used.

There is also an automatic steelyard



EASTMAN CLASS "B" SINGLE-ENDED WATER-TUBE BOILER

hopper weigher, to be employed where the material to be weighed comes intermittently, as from a crane grab, skip or tripping truck. Still other types are the Avery automatic aërial recording scale, intended for use with transporters and aërial tramways, the Avery suspended or crane weighing machine, and a variety of machines built for weighing grain and other purposes.

These scales are made by the Avery Scale Company, of North Milwaukee, Wis., which is the American branch of W. & T. Avery, Limited, of Birmingham, England.

The Eastman Water-tube Boiler

Herewith are sectional illustrations of two types of the Eastman water-tube boiler, one showing a plan view and elevation of the "Class *B*" single-ended boiler, equipped with the Eastman superheater, and the other an elevation of the "Class *C*" double-ended boiler, to which has been applied a Babcock & Wilcox superheater. The designer of this boiler is W. T. Eastman, of 31 Milk street, Boston, Mass.

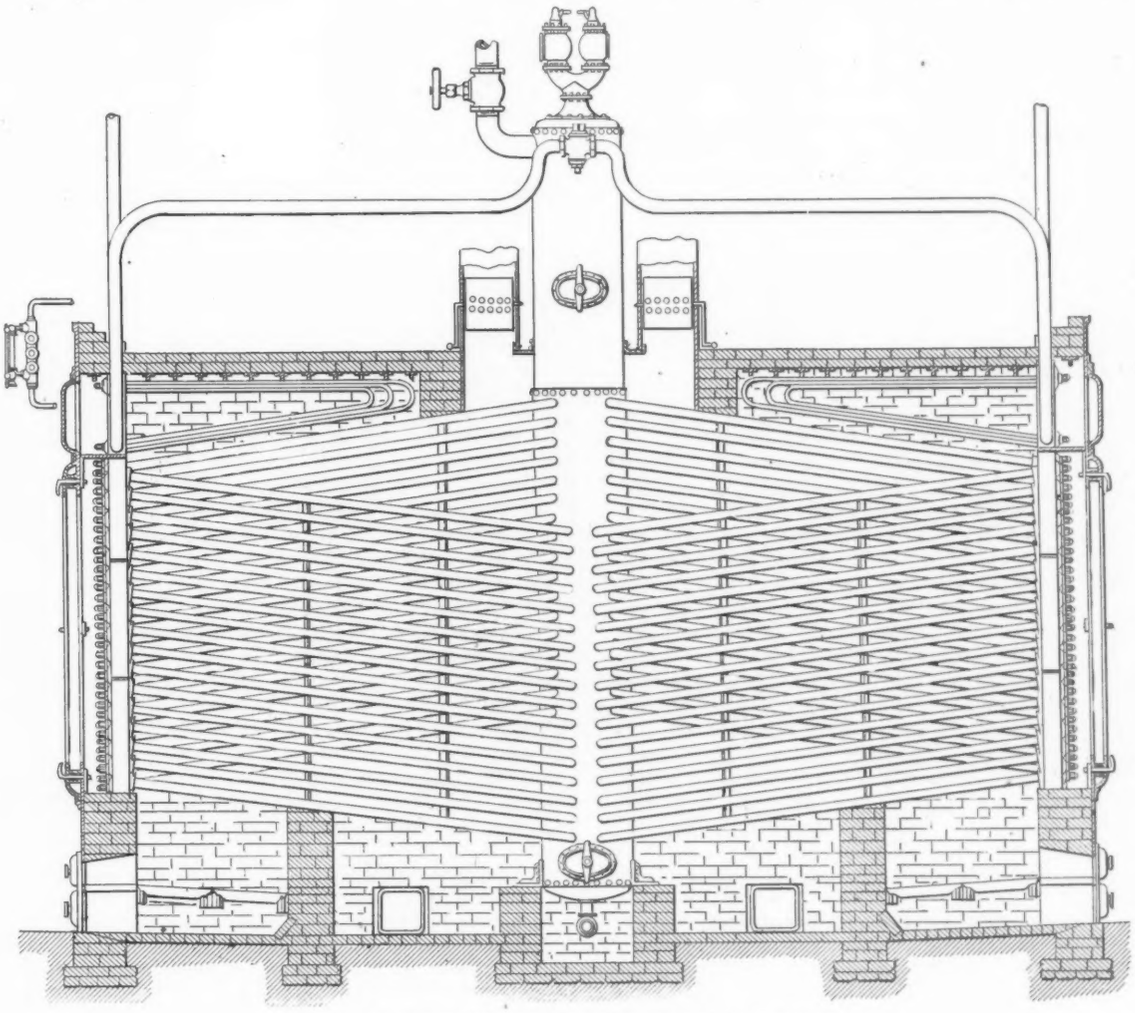
In general, the Eastman boiler combines in an original manner the characteristic elements of standard water-tube boilers, being constructed of inclined tubes, expanded into vertical drums at the rear ends and into vertical headers at the front ends. Plain vertical drums are used where hight is not restricted, while possible variations for low buildings or basement locations include a horizontal cross-drum connecting all units, or longitudinal drums above the tubes on each unit, each drum with its connecting tubes and headers being termed a unit.

Whatever the design of the upper portion, the lower section into which the tubes are expanded is a vertical, seamless, wrought-steel tube, of greater thickness than the tubes in the upper section. The drums sustain the weight of the structure without the aid of suspension frames, except in the case of attaching longitudinal steam drums, which require support at the front ends; also, one method of connecting the cross-drums, by circulating tubes, necessitates suspension of the drum. The drums can be entered through man-holes in the top and bottom for the necessary purposes of cleaning, inspection and repairs, and with modern turbine-cleaning appliances, every tube can be cleaned from within the drums, thus avoiding the removal of caps on the headers. Short tubes are inserted at the top and bottom of the drums for equalizing purposes.

The headers are either double, with straight sides, or single, of the so-called sinuous type. All are vertical, and may be of any length above that required for connecting two oppositely inclined tubes. They are constructed of wrought or cast steel, and have openings opposite the ends of all tubes. These openings are closed by either caps or hand-plates, which need not be removed except for the renewal of tubes.

The tubes are preferably of charcoal iron. Their arrangement is such that equal numbers are oppositely inclined, the object being to convey the heated water discharged into the headers back to the drums, with practically no vertical circulation in the headers. This permits the use of short headers, prevents congestion and insures rapid circulation. The tubes are straight from the front ends to a point near the drums, where they curve slightly to enter the drum-plates practically true. They can be cleaned externally with the steam lance, or by fixed pipes in a manifold system.

The hot gases are deflected vertically between the tubes by division walls, made



EASTMAN CLASS "C" DOUBLE-ENDED WATER-TUBE BOILER

up of cast-iron frames, fitted to the spaces between the tubes, filled in on one side with molded fire-bricks. The frames are adjustable, and are arranged crosswise horizontally. They can be withdrawn quickly through doors in the side walls to facilitate the renewal of tubes.

Among the "good points" claimed for the Eastman designs are the following: Being self-supporting, there are no suspension problems and any number of units may be grouped side by side to form single boilers of large capacity. The short headers and return-tube arrangement make it possible to carry the tubes to any desired hight, increasing the practicability of erecting enormous steaming capacities upon restricted floor spaces. The vertical drums contribute to the safety of the boiler; they are not exposed to gases of high temperatures, they collect loosened scale and sediment at a point where overheating cannot result from the heaviest accumulations, and they insure an abundant supply of water to every circulating tube. Incrustation will not form in the tubes as quickly or heavily as where circulation is restricted. The tubes are free to expand or contract without subjecting the headers to dangerous stresses; they accomplish practically all the work of evaporation, reducing the gases to low temperatures before they come in contact with the drum.

The double-ended boiler is said to be a more efficient steam generator than any single-ended design, chiefly because the heat loss by radiation is less per horsepower. The control of the feed-water and the various safety appliances is confined to one end.

Weber Steel-concrete Chimneys

An important feature of the power plant of the Potomac Electric Power Company, of Washington, D. C., which received only a brief mention in the description of the plant in May POWER, comprises three reinforced-concrete stacks which were built by the Weber Steel Concrete Chimney Company, of Chicago. The following description of these "monoliths" will serve to give an excellent idea of the construction of Weber chimneys in general.

The chimneys are 200 feet high and each is 12 feet in inside diameter, with two flue openings. The depth of the foundation below grade is 8 feet and each foundation is 30 feet square. The minimum loading on the soil is approximately one ton per square foot. The mixture used in the foundation is composed of one part cement, three parts sand and five parts gravel. The chimneys were designed to withstand a wind pressure of 50 pounds per square foot (a velocity of 100 miles an hour), and each chimney is anchored into the foundation, the anchorage being secured beneath two horizontal networks of T steel, laid both parallel and diagonally in the foundation, one layer being about 5 inches above the other.

The hight of the double part of each chimney is 66 feet above grade, the outer and inner walls of this section being each 4 inches thick, with a 4-inch air space between to allow for expansion and contraction of the inner wall, and also to shield the outer wall from the direct effect of the heat. Incidentally, the outer shell protects the inner from the effects of the weather and temperature changes. Ordinarily the thickness of the outer shell of the bottom part may be from 6 to 12 inches, depending on the hight, the single shell above being from 4 to 10 inches thick. The hight of the double-shell section depends upon the purpose of the chimney, nature and heat of the gases, etc.

At the 66-foot point the outside diameter is decreased to form an offset, the in-

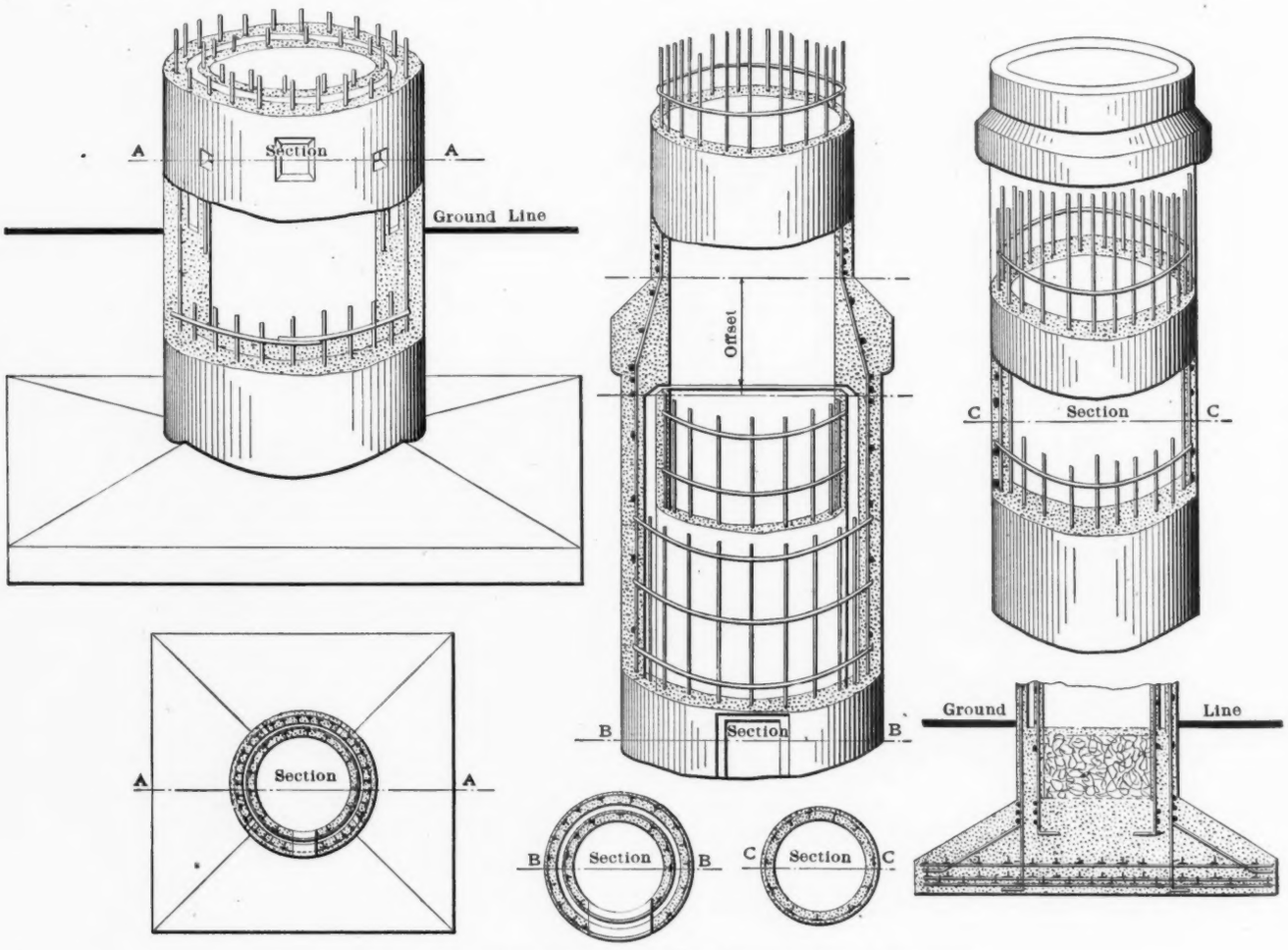


FIG. I. DETAILS OF CONSTRUCTION, WEBER STEEL-CONCRETE CHIMNEYS

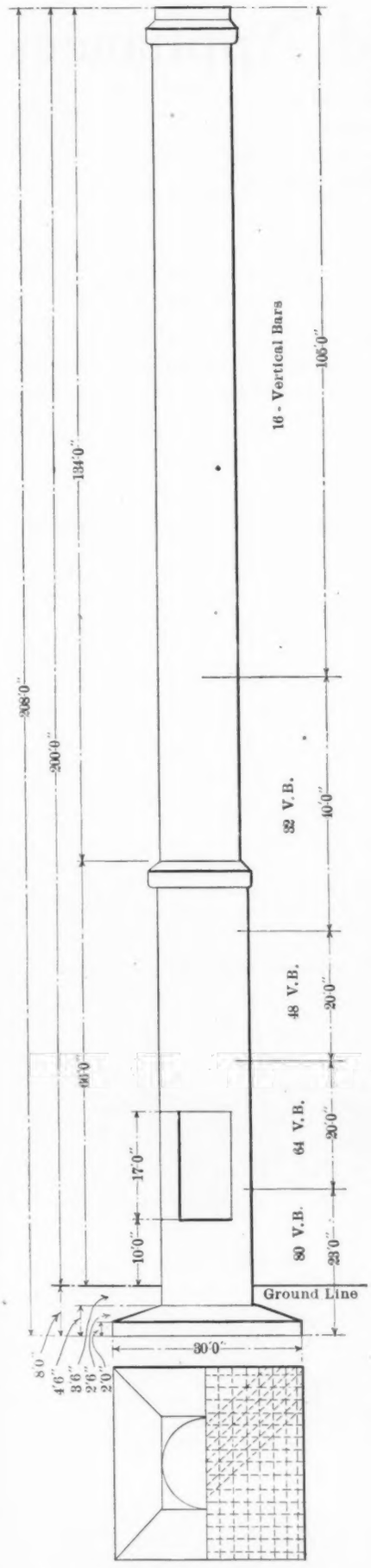


FIG. 2. SEMI-DIAGRAMMATIC SKETCH OF WEBER CHIMNEY

side diameter remaining the same, and from this point to the top there is no lining. An expansion joint is provided where the upper and lower sections meet. There is no connection between the upper section and the lining of the lower shell, and the lining is free to expand and contract in every direction. The single upper shell is 6 inches thick. The mixture used in the chimney itself, above grade, comprises one part cement and three parts clean, sharp sand.

Vertical T bars, 1¼x1¼x3/16 inches, are used to reinforce the shells and take up bending forces, it having been found that this form of bar provides about 2½ times the surface area for the adhesion of the concrete that is afforded by either a square or round bar of the same weight. The vertical bars in the base extend down into the foundation, where several of them are bent so as to effect good anchorage. The steel for the bars is from 16 to 30 feet in (mill) length, and wherever ends meet they are overlapped not less than 24 inches.

Horizontal steel rings made of ⅝-inch round stock encircle the vertical bars at 18-inch intervals (between centers), to take up shearing stresses.

The forms into which the concrete is tamped are each made up of eight sections held together by latches.

All scaffolding and work are done from the inside of the chimney. In the case of the Washington plant, on the lower or double part of each chimney, work progressed about at the rate of three feet per day; on the single shell 6 feet of concrete was placed daily, the workmen not being hampered by air-space forms or lining work.

The accompanying line drawing, Fig. 1, shows in detail the method of placing the steel at the grade line, and at the offset, both in the inner and outer shells, and also the section above the offset. Fig. 2 is a semi-diagrammatic sketch of the stack, showing section hights, etc.

The half-tone engraving, Fig. 3, gives a view of three stacks built for the Illinois Steel Company at South Chicago, Ill.; these are typical examples of Weber chimneys, of which a great many have been erected in this country and abroad.

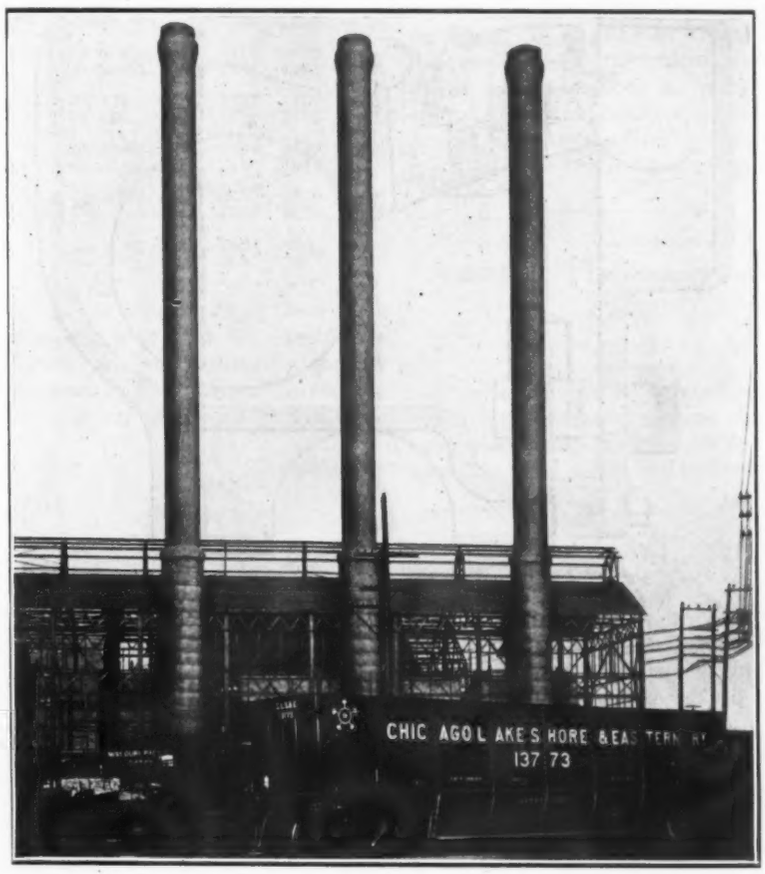


FIG. 3. WEBER STACKS FOR ILLINOIS STEEL COMPANY

For office buildings and warehouses Weber chimneys are usually built with "all-single" shells, and for short chimneys which are exposed to tremendous heat, as in glass works, a double shell throughout is generally preferred.

At Chicago, Ill., a coroner's jury found Armour & Co. indirectly responsible for the death of six workmen through the bursting of ammonia pipes, May 23. The jury also recommended the passage of a city ordinance providing for the inspection of all pipes containing gases or liquids under pressure.

Power Plant Machinery and Appliances

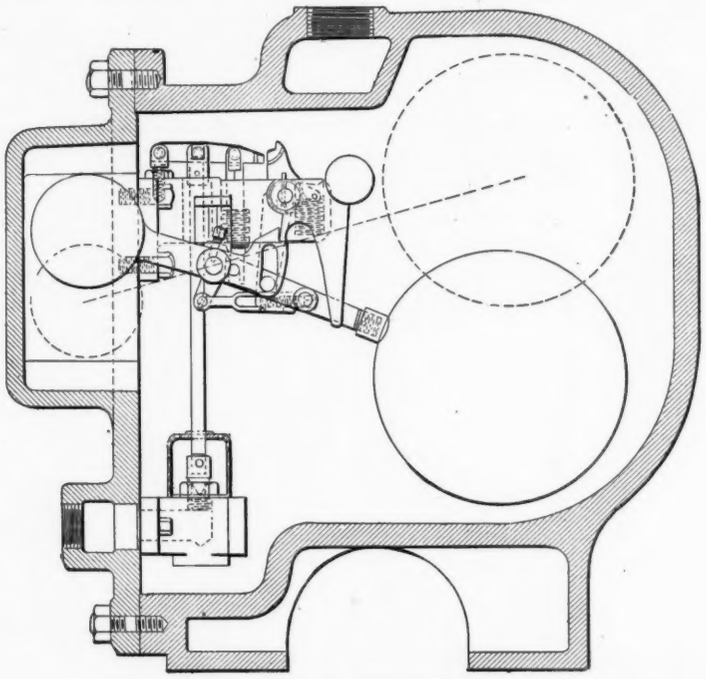
Original Descriptions of Power Devices
No Manufacturers' Cuts or Write-ups Used

MUST BE NEW OR INTERESTING

The "Wyoming" Steam Trap

The "Wyoming" steam trap, which is shown in section herewith, is the product of W. H. Nicholson & Co., Wilkes-Barre, Penn. Unlike many traps, it does not depend directly upon the buoyancy of the float to lift the discharge valve, the function of the float being to release, at its highest and lowest points of travel, a latch which in turn opens or closes the valve. The valve movement is quick-acting and the valve is entirely opened or closed at all times, avoiding any likelihood of "wire-drawing" of the water.

The "Wyoming" trap is designed to work at any pressure up to 150 pounds. It is made in four standard sizes.



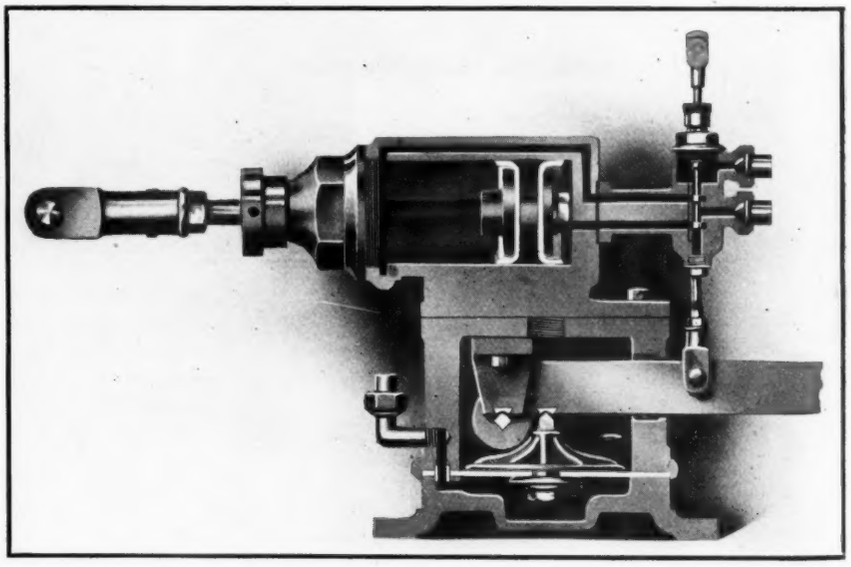
SECTIONAL VIEW OF "WYOMING" STEAM TRAP

Mason Horizontal Pressure Regulator

The Mason horizontal pressure regulator is designed to be used for controlling power and elctrically driven pumps of all types, including those employed in vacuum systems. It consists of a horizontal cylinder and piston controlled by a double-acting pilot valve, which admits and exhausts pressure to and from either side of the piston. The pilot valve is actuated by a weighted beam, which is suspended on hardened-steel knife edges, and is lifted by a rubber diaphragm against the downward pull of the weights on the beam. The fluid, the pressure of which is to be controlled, is admitted to the chamber beneath the diaphragm. Water under pressure is passed by the pilot valve for operating the piston, and can be taken from any source where a clean supply of sufficient pressure can be obtained. This pressure, it is stated, should not exceed 200 pounds per square inch, while 100 pounds is preferable. Less pressure may be used, however, if sufficient power is otherwise provided to operate the mechanism. The piston is 3 inches in diameter, having an area of about 7 square inches, and can be furnished with any stroke up to 10 inches.

The type of regulator which is shown in section herewith will make a complete stroke with a slight change of the controlling pressure, but where a graduated step-by-step movement is required, as for operating electric rheostats, the controller is furnished with a compensating device to prevent its making its complete stroke with each slight variation of pressure. Where a definite variation in pressure between stopping and starting is required, the controller is equipped with a variating attachment, to stop the pump at the pressure desired and allow any predetermined drop in pressure to occur before the pump is again started.

Where a continuous slow movement of the piston in one direction is required, and normal speed on the return stroke, there is furnished a slowing device which consists of an adjustable check-valve in the passage leading to one end of the operating cylinder, and an adjustable needle valve located in a by-pass around the check-valve. To slow the piston in both



MASON HORIZONTAL PRESSURE REGULATOR

directions, a small cock is attached to the exhaust from the pilot valve, which can be adjusted to slow the travel as desired.

This pressure regulator is manufactured by the Mason Regulator Company, Boston, Mass.

The Parr Calorimeter

The Standard Calorimeter Company, of East Moline, Ill., has the manufacture and sale of the Parr calorimeter, a patented device, covering the use of sodium peroxide and accessory materials essential for producing a complete combustion of coal and fuels of the hydrocarbon class. These instruments were first put on the market in 1900, and are now in general use in this country and Europe. A ready understanding of the method of operation may be gained from Fig. 1 herewith.

The main feature of the instrument resides in the combustion bomb *B*, which is provided with four short turbine wings, and, being concentric, the bomb turns upon its own axis, thereby thoroughly stirring the water in the can *A A*. Insulation is effected by double-fiber vessels with air space on all sides, including the cover. The bomb itself is readily opened to receive the different materials which are thoroughly mixed by shaking. Ignition is effected by dropping a short piece of hot wire through the stem which has an opening closed at the lower end by a spring valve, or by means of an electric fuse, as indicated in the illustration of the bomb, Fig. 2.

COMPARATIVE CALORIMETER VALUES.

No.	Samples.	Mahler-Atwater.	Parr.	Variation from Mahler-Atwater.
74.	Livingston Co., Ill...	5709	5673	+36
75.	Livingston Co., Ill...	6000	5952	+48
76.	Livingston Co., Ill...	5902	5860	+42
77.	Livingston Co., Ill...	5409	5460	—51
79.	Livingston Co., Ill...	5864	5888	—24
80.	Livingston Co., Ill...	5797	5757	+40
81.	Sangamon Co., Ill....	5869	5841	+28
82.	Sangamon Co., Ill....	5858	5780	+78
84.	Montgomery Co., Ill..	6459	6511	—52
85.	Montgomery Co., Ill..	6197	6234	—37
86.	Montgomery Co., Ill..	5944	5907	+37
87.	Sangamon Co., Ill....	6112	6055	+57
88.	Sangamon Co., Ill....	6323	6302	+21
89.	Sangamon Co., Ill....	6327	6293	+34
90.	Sangamon Co., Ill....	6127	6091	+36
91.	Macoupin Co., Ill....	6261	6319	—58
92.	Macoupin Co., Ill.....	6307	6368	—61
93.	Macoupin Co., Ill.....	6213	6293	—80
94.	Madison Co., Ill.....	6018	6043	—25
95.	Morgan Co., Ill.....	6144	6156	—12
96.	St Clair Co., Ill.....	6394	6408	—14
97.	St. Clair Co., Ill.....	6485	6440	+45
6290.	Williamson Co., Ill.	6957	6975	—18
6121.	Williamson Co., Ill. Float.	7738	7718	+20
6122.	Sangamon Co., Ill..	6376	6422	—46
6123.	Sangamon Co., Ill.. Float.	7246	7291	—45
6128.	LaSalle Co., Ill....	7733	7701	+32
6129.	LaSalle Co., Ill.... Float.	7158	7183	—25
6130.	Sangamon Co., Ill..	6864	6816	+48
6131.	Sangamon Co., Ill.. Float.	7388	7370	+18
6132.	Vigo Co., Ind.....	6550	6515	+35
6133.	Vigo Co., Ind..... Float.	7705	7707	—2
6134.	Sullivan Co., Ind..	7921	7855	+66
6135.	Sullivan Co., Ind.. Float.	7557	7517	+40

The rise in temperature is read by a thermometer graduated to 1/20 degree Fahrenheit and standardized by the national bureau at Washington. In addition to the 10 grams of sodium peroxide and ½ gram of finely powdered coal, there is used ½ gram of finely divided potassium chlorate. This combination gives a perfect combustion with a quiet fusion free from boiling and gas pressure. The heat value of the chemical used is carefully determined and remains constant.

Standardization of the instrument is secured by use of material readily obtained in the pure state, such as benzoic acid. These instruments are regularly employed on petroleums as well as coals and coke. An interesting feature is the ease with which ash and cinder may be tested to determine the amount of heat remaining in the unburned coal. The residues from use of this instrument furnish the most convenient medium for determining either the total carbon or sulphur content of the fuel employed.

It may be of interest in this connection to give a series of results on a large number of coals obtained by means of this instrument and paralleled by results obtained under the same conditions by the Mahler-Atwater oxygen bomb. The latter apparatus is platinum lined, and of the very best type, corrections being made in the final calculations for radiation, nitric and sulphuric acids, the outfit itself having been standardized by means of sugar, naphthalene and benzoic acid.

Automatic Pressure Recording Gage

This instrument is designed especially for use on hydraulic presses, wheel or otherwise, such as are used for forced fits, etc. The chart, which is 8 inches in diameter, is arranged to revolve automatically after each application of pressure, recording several applications on one chart. Thus, by means of such a gage, the operator can record the different operations

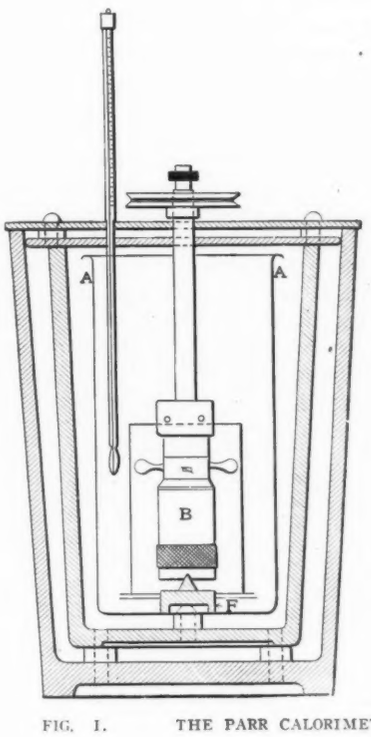


FIG. 1. THE PARR CALORIMETER

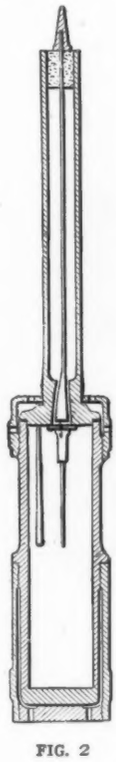
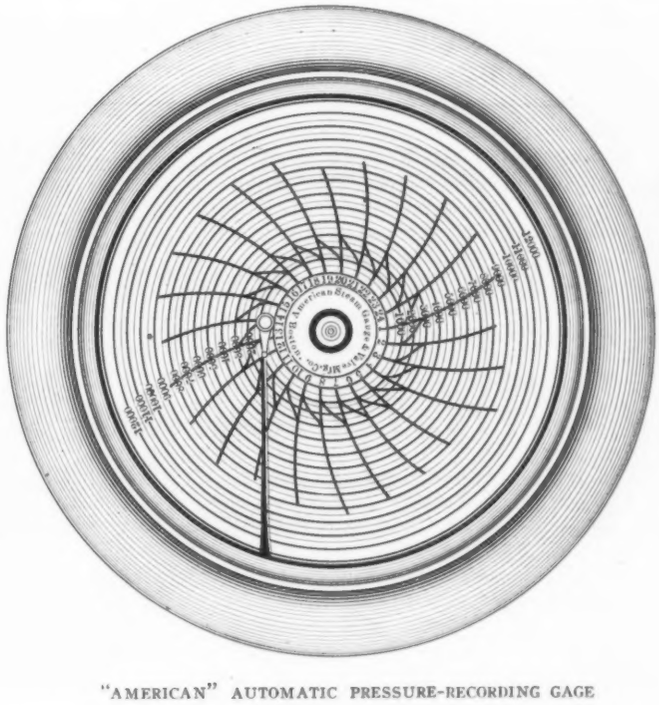


FIG. 2



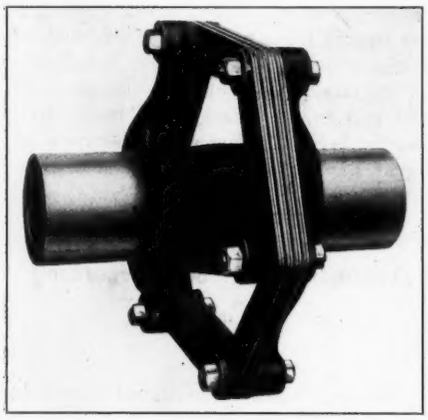
"AMERICAN" AUTOMATIC PRESSURE-RECORDING GAGE

involved in driving crank-pins, hubs, spiders, etc., to place; and the chart may be graduated to read pounds per square inch, or tons on the ram. Furthermore, the charts may be filed for reference. In the illustration is indicated the kind of record made by the pointer, the record being in red ink.

This is believed to be the only automatic hydraulic chart-recording gage on the market. It is made by the American Steam Gauge and Valve Manufacturing Company, Boston, Mass.

Flexible-link Coupling

Herewith is shown a new type of coupling which has been placed on the market



A FLEXIBLE-LINK COUPLING

by the Bruce-Meriam-Abbott Company, of Cleveland, O. It is a "flexible-link" coupling especially adaptable to electrical, air-compressor and direct-connected gas-engine work, or wherever the necessity exists for flexibility between the motor and the apparatus to be driven. Particularly, if used to connect a motor to electric-driven machinery, it allows the motor to find its own magnetic field, and takes up the jar of the machinery.

In its common form the coupling consists of two spiders, each having three arms. One spider acts as the driving member, the other being driven by it through the leather links connected from arm to arm, as shown in the illustration. It is regularly built in sizes from ¼ to 500 horse-power.

Improved McClave Grate

This grate, which is made by the McClave-Brooks Company, of Scranton, Penn., differs in point of construction from the McClave grate No. 1, which has been described in POWER, in the design of the grate bars, which in the No. 2 grate are made with removable sectional tops and shanks, mounted in a socketed body. It is pointed out that the importance of this feature lies in the top portions of the bars being cast separately, the body portion containing sockets to receive the shanks of the tops. In case one of the tops should be broken, only one top section would have to be replaced, instead of a whole bar. The tops are held in place by a soft-steel lug in the base of each shank, bent under the bottom of the bar.

The top view in the cut, Fig. 1, shows the back of a bar, complete, and the lower view, together with the cross-sectional view in Fig. 2, illustrate the construction of the tops and body. The intermediate tops are of uniform width, and therefore interchangeable, while the end tops vary in width for different sizes of bars. These bars are made with air-spaces graduated to suit various sizes of fuel, the smallest being 5/32 inch.

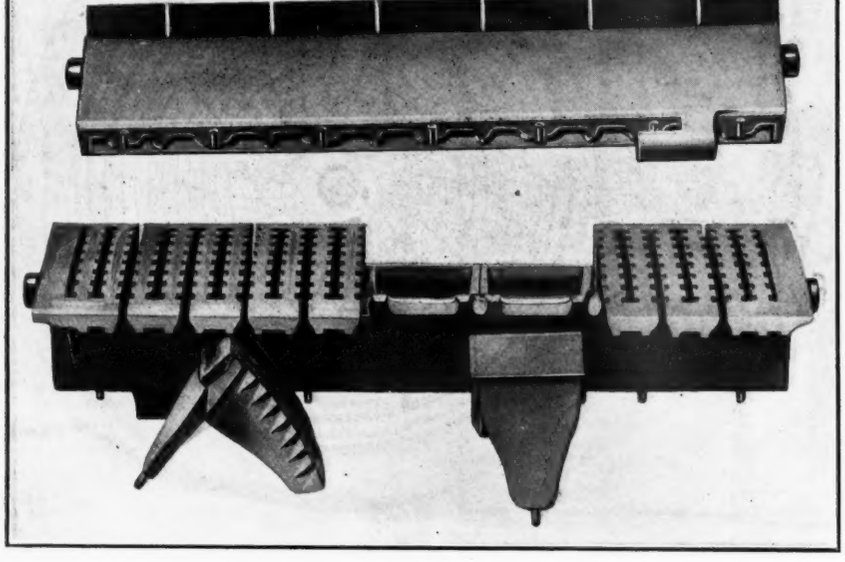
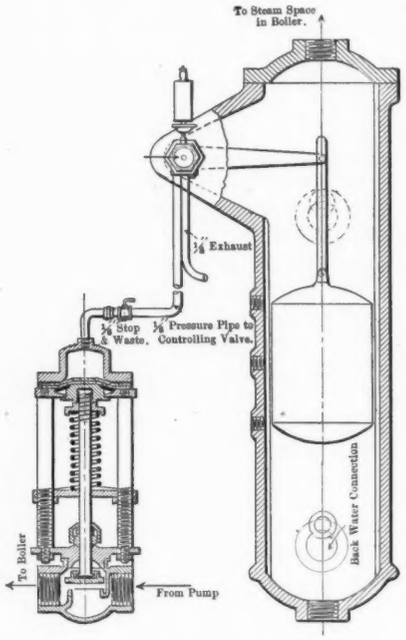


FIG. 1. DETAILS OF GRATE BAR FOR M'CLAVE GRATE NO. 2

Berry Safety Automatic Feed-water Regulator

Herewith is shown a sectional view of the improved Berry safety automatic feed-water regulator, manufactured by the Berry Engineering Company, of Chester, Penn. It consists essentially of a float connected to a lever which operates a pilot valve as the water rises or lowers in the column, its operation depending upon gravity alone, that is, in the rise and fall of water. There are no internal valves, and no expansion tubes.



BERRY AUTOMATIC FEED-WATER REGULATOR

The operation of the regulator is as follows: The float, rising with the water, pushes up the lever connected with the pilot valve and rotates the latter just enough to allow steam to enter the ⅛-inch pipe and exert pressure on the diaphragm of the controlling valve, shutting off the water from the boiler. This operation takes place when the water is at the center gage. As soon as the water line falls below the center gage, the float falls with the water and rotates the pilot valve in the opposite direction, allowing the pressure on the diaphragm to be released

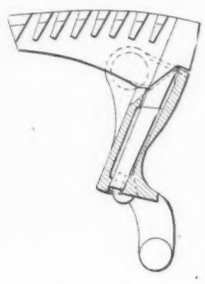


FIG. 2. CROSS-SECTION OF BAR

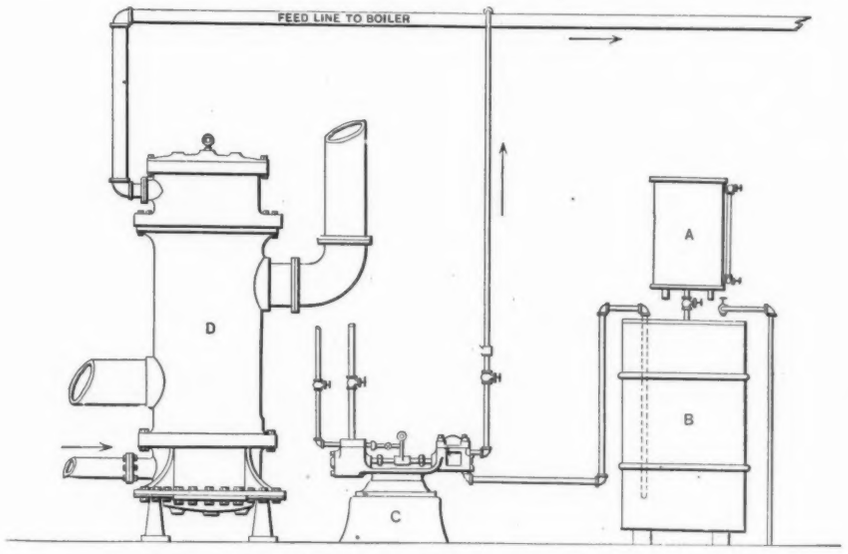
and permitting the controlling valve to open and allow the feed-water to flow into the boiler. When enough water has entered the boiler to fill it to the center gage again, the controlling valve closes again. The idea is that the operation will be repeated indefinitely, holding the water within ½ inch of the center gage.

Should the water supply fail from any cause and the water line fall to the bottom gage cock, the float, falling with the water, will rotate the pilot valve enough to allow steam to enter the whistle port and sound an alarm.

The float is 5¼ inches in diameter and 8 inches long. The controlling-valve diaphragm is supported by steel plates. The pilot valve can be removed while steam pressure is on the regulator, and the regulator can be inspected while under pressure. The alarm can be adjusted to blow for high and low water, with a variation of from 2 to 6 inches above and below the center gage.

Constant-feed Method for Boiler Compounds

An apparatus designed by the Bird-Archer Company, of New York City, for constantly feeding boiler compound to boilers is illustrated herewith. After diagnosis of the boiler conditions, including the character of the feed-water, the precise nature of compound which it is expected will do the work is selected and the quantity requisite for a day's run is determined. This is placed in a 10-gallon supply tank *A*, fitted with a gage glass and a valve to regulate the rate of drip from this tank into a 60-gallon mixing drum *B*, in which the compound is thoroughly mixed with water coming from the supply pipe *E*. The supply of mixing water and dripping compound may be regulated by valves so as to be properly proportioned to each other and to the amount of feed-water. To further increase the mingling of water and compound, the suction pipe of the small auxiliary feed pump *C* is led through the top of the mixing tank. This pump runs steadily and handles nothing but compound-charged water, which it delivers to the main feed pipe of the boilers between the feed-water heater and the check valve. With the main feed coming in steadily and the auxiliary or compound feed injecting into every pump barrel-full its quota of compound, it would seem that there is an ideal dissemination of compound throughout the feed-water, enabling the compound to act at once on all parts.

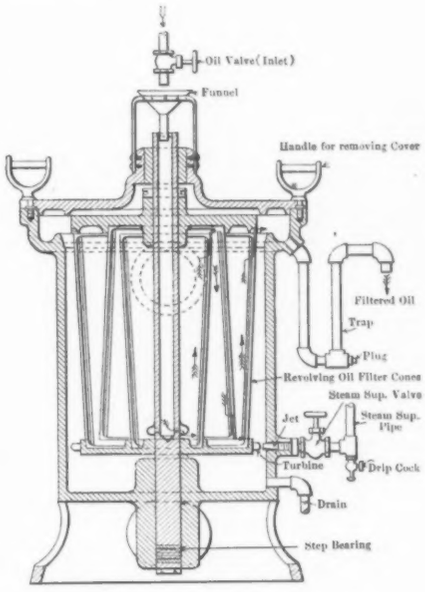


BIRD-ARCHER CONSTANT-FEED METHOD FOR BOILER COMPOUNDS

A Turbine Centrifugal Oil Filter

The Oil and Waste Saving Machine Company, of Philadelphia, is manufacturing a "turbine centrifugal oil filter." It is continuously operated by means of a steam turbine, the oil being introduced into the filter through the shaft of the turbine, while in operation. It is then sprayed on filtering cloth and filter paper, the filtering material being revolved by the turbine. Centrifugal force carries the oil through the filtering material, and so on to the cutlet.

This filter consists of three brass cones or conical bowls, arranged as shown in the illustration, the first one being held at the base, the second one at the top, and the outside one both at the top and bottom, with holes at the top through which the oil passes. Inside of these brass cones are placed brass wire-gauze cones with curved solid pieces at the top and bottom. These wire-gauze cones are for the purpose of holding the filtering cloths and keeping the cloths away from the solid cones, so that the oil will have a free passage up and down the different cones. In the outside cone between the filter cloths is inserted filter paper. The thickness of the filter cloths varies in the different cones.



TURBINE CENTRIFUGAL OIL FILTER

The cones are all revolved by the steam striking the turbine blades at the base. While at full speed, the oil is allowed to run into the hollow shaft and is thrown from the shaft by centrifugal force through a sprayer at the bottom of the first cone and against the filtering medium. It is carried through this filtering medium and, striking the solid brass cone, is carried up to the top by the centrifugal force. This top being open, the oil is thrown against the filtering medium in the second cone, passing through it and down to the bottom, where it is thrown over against the filtering medium of the third cone, in this way going up and down the cones until it is discharged at the top and into a trough, the course being indicated in the illustration by arrows. From here it is drained off through a trap arranged to form a seal so as to prevent the steam exhausting with the oil. No part of the trap is a high as the trough, therefore the accumulating oil discharges freely.

To clean the filter the handles shown in the illustration are unscrewed, allowing the entire top to be readily removed. Similar handles are placed in the top plate holding the cones and allow the plate to be raised over the shaft. With this top plate is carried the central cone. The wire-gauze cones holding the filtering mediums are then withdrawn and new filtering mediums can be put in, the entire operation taking about five minutes.

It is pointed out that as the oil is first thrown through the filtering material at the base of the inner cone, when that part of the filtering medium becomes filled with dirt the oil flows up and goes through a

clean part, and so on until it is time to renew the filtering material. The second and third cones are employed to remove the fine particles which may have passed through the preceding sections.

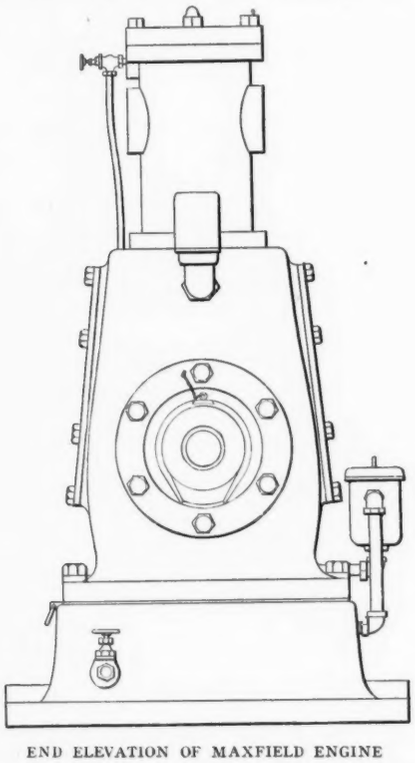
The Maxfield Steam Engine

The Maxfield steam engine, sectional and end elevations of which are shown herewith, is of the vertical, double-piston single-acting type, with two trunk pistons set side by side, the connecting-rods being directly attached to pins set at 180 degrees. The pistons are made extra long to provide for lateral pressure, and the action being always downward the danger of pounding is obviated. The moving parts are entirely closed in a cast-iron crank-case, which renders the engine dust-proof, and makes it especially suitable for use where the atmosphere is filled with dust and grit.

The valve is of the rotating type, doing away with eccentric and strap, which are replaced by bevel gears. An ordinary throttle governor is used.

The engine is of the internal self-oiling type, all the working parts, including the main bearings, running in an oil bath. With the exception of the cylinder lubricator, there are no oil nor grease cups. The oil chamber has a capacity of about one gallon, and a gage indicates the hight of pure oil in the chamber.

The Maxfield engine is built for stock in sizes ranging from 3 to 30 horse-power,

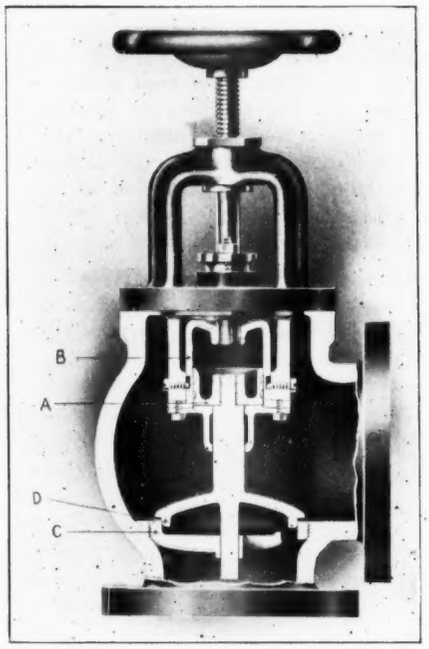


END ELEVATION OF MAXFIELD ENGINE

for all speeds up to 1000 revolutions per minute, by the Empire State Engineering Company, foot of East One Hundred and Sixteenth street, New York City.

Locke Automatic Non-return Stop Valves

Accompanying is a sectional view of the most recent pattern of automatic non-return stop valves, for use between the boiler and the main steam line, made by the Locke Regulator Company, Salem, Mass. The feature to which the maker directs attention is the method by which chattering and beating out of the valve seat are prevented, by providing for the withholding of the valve from its seat without interfering with its functions. Reference to the cut will show how this is accomplished. The piston *A* comes face to face with and is cushioned upon the bottom of the cylinder *B*, and holds the valve above its seat *C* about one-fourth of an inch, and the closely-fitting extension *D* entering the valve opening stops the flow of steam. Thus the valve seats are always in good condition for service whenever it is necessary to close the valve by the hand-wheel and screw, in which operation the screw first strikes the piston and forces the cylinder *B* down with it far enough to close the valve. When opened, the cylinder is drawn up again, as shown in the cut. These valves are tested to withstand a working pressure of 250 pounds.

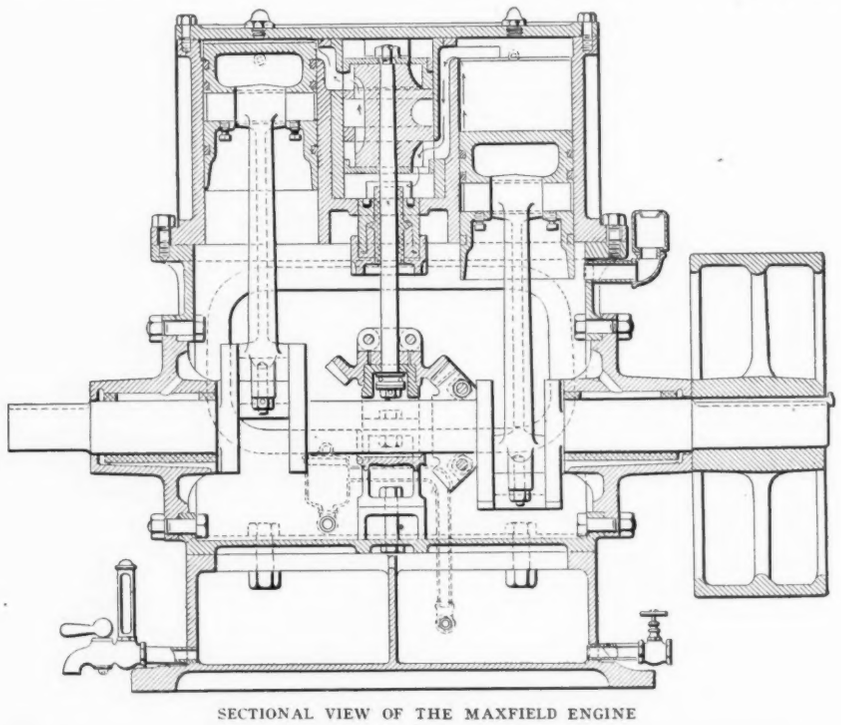


LOCKE AUTOMATIC NON-RETURN STOP VALVE

Goetze's Cement

The American Goetze-Gasket and Packing Company has just put on the market a new cement, known as "Goetze's Cement," adapted for use on steam-, gas- and water-pipe joints. It is plastic, having a putty-like consistency, and is therefore easily and quickly applied. It is claimed for it that it is of tough, elastic firmness, withstands heat, cold and dampness, is not affected by acids, lyes, etc., and is non-poisonous. It is especially recommended for use with the well-known Goetze corrugated copper gaskets.

It is said that 70 per cent. of the output of machine tools by the Niles-Bement-Pond Company are driven by individual motors, and that the same condition obtains for 50 per cent. of the products handled by Manning, Maxwell & Moore.



SECTIONAL VIEW OF THE MAXFIELD ENGINE

Inquiries

Questions are not answered unless they are of general interest and are accompanied by the name and address of the inquirer.

Saving by Heating Boiler Feed-water

What is the rule for calculating the saving effected by heating the feed-water for a steam boiler?

J. R. S.

The formula is

$$\frac{h_w - h_c}{H - h_c} = C,$$

in which

H = B.t.u. in 1 pound of steam at the pressure carried,
h_w = B.t.u. in 1 pound of water at the temperature acquired in the heater.
h_c = B.t.u. in 1 pound of unheated water,
C = Proportion of coal consumption saved by heating.

For example: Suppose a boiler is supplied with cold water at 50 degrees Fahrenheit and a steam pressure of 90 pounds gage is carried; also suppose the coal consumption is 9 tons of coal per week at $3 per ton. If a feed-water heater be installed and the feed-water be heated by exhaust steam from the engine up to 200 degrees temperature, the saving will be

$$\frac{168.7 - 18}{1182.84 - 18} = 0.1294$$

of the coal consumption with cold feed-water. This being 9 tons per week the saving will be

$$9 \times 0.1294 = 1.164 \text{ tons}$$

the value of which is

$$1.164 \times \$3 = \$3.49$$

Coal Necessary to Evaporate a Tank of Water into Steam

We have a circular tank full of water, the tank is 12 feet diameter on top and 15 feet at the bottom, and is 15 feet deep. The water in the tank is 100 degrees Fahrenheit. How much coal will it take to evaporate the water into steam?

J. B. S.

This cannot be solved without knowing the steam pressure, heat value of the coal and the efficiency of the boiler. The tank contains

$0.7854 \times 13.5^2 \times 15 = 2147.1$ cubic feet; water at 100 degrees weighs 62.02 pounds per cubic foot. The tank, therefore, contains

$2147.1 \times 62.02 = 133{,}163.142$ pounds of water. One pound of water at 100 degrees contains 68.08 B.t.u.; one pound of steam at atmospheric pressure contains 1146.6 B.t.u.; there is required, therefore,

$1146.6 - 68.08 = 1078.52$ B.t.u., to evaporate each pound of water at atmospheric pressure. Hence:

$1078.52 \times 133{,}163.142 = 143{,}619{,}110$ B.t.u., which will be required to evaporate the tank full from the initial temperature of 100 degrees. The pressure of evaporation was not stated, and has been assumed at atmospheric.

Dividing the above figure by the B.t.u. per pound of coal will give the quantity of coal required if the boiler had no loss.

Why Solids in Solution Raise the Boiling Point of Water

Why does water containing a solid in solution boil at a higher temperature than pure water?

Is the difference of temperature the same between the boiling point of pure water and water containing a particular quantity of a solid in solution, no matter what the pressure is? For example, if both are boiling at one pound absolute and the difference of temperature is 5 degrees, will the difference of temperature be 5 degrees when both are boiling at 100 pounds or 150 pounds absolute? J. C. M.

The rational explanation of the fact that the boiling point of water containing a solid in solution is higher than that of pure water, is that the repulsive force of the molecules has, before the point of disruption is reached, to be great enough to overcome not only the cohesive force of the molecules themselves, but the chemical affinity of the material in solution for the water. As this disruptive force is due to the energy of the molecules, which is simply their temperature, the boiling point is higher. Dalton established the law that the difference of the temperatures of the boiling points of liquids is constant under all variations of pressure, and we do not know that solutions of solids in water are any exception to the rule.

To Figure the Size of the Low-pressure Cylinder

We are putting in a pair of compound engines in a mine, and we have a steam pressure of 150 pounds per square inch; our high-pressure cylinder is 20 inches by 28 inches. What size would you have your low-pressure cylinder?

J. B. S.

Expanding down to 16½ pounds absolute pressure gives 10 expansions, and these should be divided between the two cylinders about equality. If the high-pressure valve cuts off at 0.3 stroke, this will give 3⅓ expansions, ignoring clearance, and the low-pressure cylinder will have to give 3 expansions to make up the total of 10. Its area, therefore, will have to be three times that of the high-pressure cylinder, and the diameter will have to be 34.64 inches to get that ratio of areas.

Paralleling Composite-wound Alternators

Is it necessary to use an equalizer between two composite-wound alternators operating in parallel? If not, why not?

W. R. P.

No; because the division of load between alternators is not affected by variations in field excitation.

Size of Wire for Electrical Circuit

In POWER for February, 1905, there was given the following formula for the size of wire to carry electric current:

$$\frac{11 \times L \times C}{v} = \text{circ. mils},$$

in which

L = Length of wire, in feet,
C = Current, in amperes,
v = Drop, in volts.

In the *American Electrician* a year or two ago there was the formula:

$$\frac{22 \times D \times C}{v} = \text{circ. mils.}$$

Which is correct?

J. W.

Both. In the first formula the length of the wire is given; in the second, the distance (D) is given. The distance being half the actual length of wire (a two-wire circuit is evidently meant), it is necessary to multiply it by 22 instead of by 11 in order to get the same result. Thus, if the distance be 1000 feet, the actual length of wire will be 2000 feet, and 22×1000 is the same as 11×2000.

Gas-engine Compression and Efficiency

How is the compression of a gas engine determined and why does increasing it increase the efficiency? H. Y. W.

The compression depends on the ratio of the clearance volume in the cylinder to the total volume behind the piston when the crank is on the outer or distant center (in a double-acting engine, the center which puts the piston farthest from the end of the cylinder under consideration). Assuming that the inlet valve remains open throughout the suction stroke, the compression pressure, with ordinary explosive mixtures, is given by the formula:

$$P_a \times \left(1 + \frac{V_s}{V_c}\right)^{1.3} = P_c,$$

in which

P_a = Absolute pressure at beginning of compression stroke,
V_s = Volume swept out by piston during compression stroke,
V_c = Volume of the clearance space,
P_c = Absolute pressure at end of compression stroke.

Increasing the compression increases the efficiency within certain limits, because the rise of pressure due to combustion is greater with high than with low compression, and the mean effective pressure is therefore higher. Under average conditions the pressure due to the explosion of the mixture is proportional to the heat units in the mixture divided by its specific heat (at constant volume) and multiplied by the 0.77 power of the compression pressure. With all other conditions unchanged, therefore, the explosion pressure obtained with a compression pressure of 90 pounds would be 1.7 times the explosion pressure obtained with 45 pounds compression.

Kentucky State Association Convention

The fifth annual convention of the Kentucky State Association of the National Association of Stationary Engineers was held at Louisville, Ky., June 1 and 2. The convention was opened on Saturday morning at Odd Fellows' Temple. Col. R. S. Brown, president of the Commercial Club, delivered the address of welcome, which was responded to by State President John Maconnell. J. H. Van Arsdale, of the board of trustees of the *National Engineer,* read a paper relative to that magazine and the National association in general. After the reports of the different committees were read and other important business transacted, the convention adjourned.

The entertainment features included visits to the plants of the Frank Fehr Brewing Company, the Henry Voght machine works, and the new pumping and filtering station of the Louisville water works. There was also a most enjoyable trolley trip, terminating at Fountain Ferry, where supper was served. The following officers were elected: R. Baumgarten, president; Aug. J. Pohl, vice-president; Edward Kochenrath, treasurer; Asa Williams, secretary; G. H. Rumpel, conductor; B. L. Howe, doorkeeper. Owensboro was selected as the meeting place in 1908.

New York State Convention, N. A. S. E.

The New York State convention of the National Association of Stationary Engineers was held at Rochester, N. Y., June 14 and 15. The convention was opened with prayer by Rev. Frank S. Rowland, followed by an address of welcome by Mayor James G. Cutler. Frederick Bower, State president, responded, after which there was an address by E. A. Fisher, city engineer, on "Engineers as I Find Them," which was responded to by Charles Garlick. In place of Herbert E. Stone, past National president, who had not arrived, John W. Armour entertained the convention. Theodore N. Kelsey, National president, closed the session with an excellent address on the merits of the N. A. S. E.

The entertainment included a visit to beautiful Glen Haven Park, and trolley rides to Ontario and Manitou beaches, at which latter resort dinner was served and dancing enjoyed.

On the evening of June 13 a reception was tendered to the visiting delegates, at which Frank J. Corbett and "Jack" Armour entertained.

The following officers were elected: George J. Wittman, president; J. C. Roberts, vice-president; E. E. Pruyn, secretary; Charles Schabacker, treasurer; John F. Lynch, conductor; Edward L. Edge, doorkeeper. It was voted to hold the convention of 1908 at Jamestown, N. Y.

"United Engineers of Greater New York" Opens New Rooms

Saturday evening, May 25, the United Engineers of Greater New York formally opened new headquarters at 113 Nassau street, New York City. The location of the rooms, which have been leased for three years, is excellent, and they are very attractively furnished. Among the conveniences provided are an office and a labor bureau, with telephone service. A novel plan has been adopted for raising money for running expenses. On the walls of the large room 1800 square feet of surface has been divided into panels four feet high and advertising space therein is sold to engineers' supply houses.

About 400 members attended the opening. President Thomas Keenan explained the objects of the association, which aims to bring about a shorter working day, fair compensation, improved work and better sanitary conditions. Other speakers were Thomas Trolsen, corresponding secretary, under whose direction the rooms were secured and furnished, and who designed the advertising system; Treasurer George Miller, W. D. Sprague, Patrick Phillips, George Reynolds and Arthur Curley. John W. Armour, of POWER, entertained with recitations and new stories, and materials were provided for those who cared to smoke.

The membership is increasing rapidly, it being the desire to enroll every stationary engineer in good standing in Greater New York.

The A. O. S. E. Convention

The twenty-first annual convention of the American Order of Steam Engineers was held at Atlantic City, N. J., June 10 to 14, at the Casino hall on the steel pier, there being present upward of three hundred delegates and guests. Mayor F. P. Story delivered an address of welcome, which was responded to by Supreme Chief A. J. Deidrich. After the appointment of the necessary committees and other important business, the session adjourned. There were two other business sessions, at which interesting papers were read by C. P. Williams and G. W. Richardson, and one on "Gas Engines" by W. M. Hampton, of the Westinghouse company.

The entertainment features included a yacht sail on the ocean, a trolley ride, visits to several large plants, an excursion to Somers Point, where a clambake was served, and a high-class "smokefest," at which the well-known New York "Bunch" entertained. After the entertainment W. S. Scott was presented a beautiful diamond ring, and William Lecompte was the recipient of two ferocious-looking dogs, which latter presentation provoked much merriment.

The following officers were elected for the ensuing year: Chief engineer, A. W. Deidrich; assistant engineer, J. T. Harris; recording engineer, E. H. Naylor; corresponding engineer, Fred Markoe; treasurer, W. J. Gifford; chaplain, C. R. Cook; trustees, W. S. Price, H. M. Trout, Wm. Smith.

Baltimore, Md., was selected as the meeting place of the next convention on the second Monday in June, 1908.

Obituary

John A. Walker, vice-president and treasurer of the Joseph Dixon Crucible Company, died at his home in Jersey City, N. J., on May 23. Mr. Walker was born in New York, September 22, 1837. He received his early education in the schools of Brooklyn, and, although prepared for college in a private school, chose commercial life. After an excellent business training in New York, and after serving his country in the Civil War, Mr. Walker in 1867 became connected with the firm of Joseph Dixon & Co., and in 1868, when the company became incorporated as the Joseph Dixon Crucible Company, he was made secretary of that company. Mr. Walker served as secretary and largely as manager until 1891, when he was elected to the dual position of vice-president and treasurer, the latter office having been held by him for some time previous.

As vice-president and treasurer of the Joseph Dixon Crucible Company there was more than work enough for any ordinary man, yet outside of his duty as such he was vice-president of the Colonial Life Insurance Company; director of the New Jersey Title Guarantee and Trust Company; director of the Provident Institution of Savings; president of the Children's Friend Society, all of Jersey City, and trustee of the Stationers' Board of Trade of New York. He had served as first vice-president of the National Stationers' and Manufacturers' Association. He was a member of the Chamber of Commerce of New York and of the Board of Trade of Jersey City. He was chairman of the executive committee of the Cosmos Club, a member of the Carteret Club, the Union League Club, the Lincoln Association, all of Jersey City, and of the National Geographic Society; and associate member of the American Institute of Mining Engineers, and of the Society of Physical Research.

AMERICAN ORDER STEAM ENGINEERS AT ATLANTIC CITY, JUNE 10 TO 13

NEW YORK STATE CONVENTION, N. A. S. E., AT ROCHESTER, JUNE 14 AND 15

Book Reviews

INDUSTRIAL ALCOHOL; ITS MANUFACTURE AND USES. By John K. Brachvogel. Published by Munn & Co., New York, 1907. Cloth; 516 pages, 6x8 inches; 107 illustrations. Price, $4.

This is a very comprehensive book, being substantially a compilation and adaption of material from other works. The technical chapters are chiefly excerpts from Delbrück and Lange's revision of Dr. Märcker's "Introduction to Distillation." The opening chapter on the industrial value of tax-free alcohol was contributed by Charles J. Thatcher, Ph.D., and might profitably have been omitted; it consists chiefly of a lot of over-enthusiastic predictions and statements of unpractical "possibilities." The succeeding chapters deal exhaustively with the production of alcohol, beginning with the composition and formation of starch and continuing step-by-step through the various natural and artificial processes. Part XI on Distillation and Rectification is particularly good although, like all other meritorious parts of the book, it is obviously of foreign origin and therefore relates to foreign practice. The book should be of interest to those concerned with the production of denatured alcohol on a considerable scale.

MARINE ENGINEERS AND HOW TO BECOME ONE. By E. G. Constantine. Published by the Technical Publishing Company, Manchester and London, England. Second edition. Cloth; 332 pages, 5x7¼ inches; 84 illustrations. Price, $2 net.

While this book was written by an Englishman, ostensibly to reach English parents, guardians, boys, apprentices and young engineers, it contains a very large amount of helpful observations and facts which will amply repay anybody, anywhere, to read and assimilate. It would be difficult to suggest a better method of handling a subject of such scope, beginning as it does with the renumeration of sea-going engineers, dangers of the sea, choice of schools, etc., and concluding with the duties of the junior engineer, board of trade examinations, and some sound advice to the junior who is about to apply for a first-class license. There is an absence of obscure technicalities which is refreshing. A history of the development of the marine engine and boiler, although incomplete, is notable both on account of accuracy and as a stimulus to further research. But the feature that will appeal most to our readers is in the practical portions of the marine engineer's duties, dealing with break-downs and repairs, the machinery and parts, and the like, all up-to-date and understandably described and illustrated.

THE DESIGN OF WALLS, BINS AND GRAIN ELEVATORS. By Milo S. Ketchum. Published by the *Engineering News* Publishing Company, New York; London, Archibald Constable & Co. Cloth; 393 pages, 6x9 inches, illustrated. Price, $4.

Says the author: "The aim in writing this book has been to present a systematic analysis of the stresses due to granular materials, together with a discussion of the principles of design and the details of structures which contain the granular materials." The work treats, first, of the design of retaining walls. The design of bins for coal, ore, etc., comes next, followed by the design of grain bins and elevators. Both algebraic and graphic methods have been employed, as seemed suitable, and two chapters are devoted to Rankine's and Coulombe's theories. The work includes a discussion of the theory of reinforced concrete, together with necessary formulas. It is replete with experiments and examples, details of cost, etc., and although it is announced as a first contribution to bin design, it is remarkably comprehensive.

UNIVERSAL DICTIONARY OF MECHANICAL DRAWING. By George H. Follows. Published by the *Engineering News* Publishing Company, New York. Cloth; 60 pages, 8x10¾ inches, illustrated. Price, $1.

While the author's stated intention is to present a work that shall make for uniformity in drawings of the character designated, so that draftsmen and students may all show sectionings and other characterizations alike, the "dictionary" is sure to appeal to the amateur who has experienced perplexity when trying to draw a sketch to illustrate some point, as in a letter for publication. The correct names of lines and parts are concisely given, and clearly defined. There are other helps in the way of abbreviations, tables of standard data, concluding with a chapter of sample drawings. This dictionary was first published in parts in the *Engineering News*.

OPEN HEARTH STEEL CASTINGS. By W. M. Carr. Published by the Penton Publishing Company, Cleveland, O. Cloth; 118 pages, 5½x7½ inches, illustrated. Price, $1.50.

This is a compilation from articles written by Mr. Carr and published in the *Iron Trade Review* and *The Foundry*. It treats comprehensively of the methods involved in the manufacture of open-hearth steel castings by the basic and acid processes, yet there is nothing cumbersome in the treatment. It combines theory and practice in a practical way, involving only such scientific data as were absolutely necessary to avoid slighting the subject. The work concludes with a chapter on cost of equipment.

Books Received

"Link Motion." By Fred H. Colvin. The Derry-Collard Company, New York. 82 pages, 4x6 inches. Illustrated. Indexed. Cloth. Price, $0.50.

"Manual of Wireless Telegraphy." By Frederick Collins. John Wiley & Sons, New York. 232 pages, 4½x7¼ inches. 90 illustrations. Cloth, $1.50. Morocco, $2.

"The Design and Construction of Cams." By Charles F. Smith, Frederick Halsey and others. Hill Publishing Company, New York. 70 pages, 8½x12 inches. Illustrated. Indexed. Cloth. Price, $3.

"American Stationary Engineering." By W. E. Crane. The Derry-Collard Company, Liberty street, New York. 285 pages, 5¼x7¾ inches. Illustrated. Indexed. Tables. Cloth. Price, $2.

"Concretes, Cements, Mortars, Plasters and Stucco." By Fred T. Hodgson Fred. J. Drake & Co., Chicago, Ill. Cloth; 520 pages, 5x7¾ inches; 46 illustrations Indexed. Price, $

"Tools for Machinists and Woodworkers." By Joseph Horner. The Norman W. Henley Publishing Company, New York. Cloth; 340 pages, 5x8 inches; 456 illustrations. Indexed. Price, $3.50.

"Practical Metal Turning." By Joseph Horner. The Norman W. Henley Publishing Company, New York. Cloth; 404 pages, 5¼x8¼ inches; 488 illustrations. Indexed. Price, $3.50.

"Punches, Dies and Tools for Manufacturing in Presses." By Joseph W. Woodworth, M. E. The Norman W. Henley Publishing Company, New York. Cloth; 483 pages, 5¾x9 inches; 702 illustrations. Indexed. Price, $4.

"Modern Milling Machines." By Joseph G. Horner. The Norman W. Henley Publishing Company, New York. Cloth; 304 pages, 5¼x8¾ inches; 269 illustrations. Indexed. Price, $4.

"Air Compressors and Blowing Engines." By Chas. H. Innes, M. A. D. Van Nostrand Company, New York. Cloth; 290 pages, 4½x7 inches. Illustrated. Indexed. Price, $2.

"Practical Lettering with Original System for Spacing." By Thomas F. Meinhardt. The Norman W. Henley Publishing Company, New York. Paper covered; 16 pages, 13½x9 inches. Fully illustrated. Price, 60 cents.

"The Design of Steel Mill Buildings." By S. M. Ketchum, C. E. The *Engineering News* Publishing Company, New York. 457 pages, 6x8¾ inches. Illustrated. Indexed. Tables. Cloth. Price $4.

"Metallurgy of Cast Iron." By Thomas D. West. David Williams Company, New York. 627 pages, 4¾x7¼ inches. Illustrated. Indexed. Tables. Cloth. Price, $3.

Fly-wheel Explosions

May 9 a fly-wheel attached to an engine used for driving a cupola fan in the casting department of the Allentown (Penn.) Rolling Mills, burst and caused sufficient damage to shut down the department for several days. The wheel weighed between 500 and 600 pounds. The engine has no governor.

May 25 a large fly-wheel burst in the Frost & Van Riper silk mills, West Pittston, Penn., seriously injured two men and practically wrecked the rear end of the main mill.

May 26 a 14-foot fly-wheel, attached to a Corliss engine running at 105 revolutions per minute, was wrecked at the Streator (Ill.) street railway power plant, doing considerable damage to property, but none to person. Several conjectures were formed as to the cause. It was stated that part of the fractures looked old, as if they were due to strains other than those set up by the work the engine was called upon to do. The governor is fitted with a safety stop, which is supposed to operate when the governor belt breaks or runs off the pulley. After the accident the safety stop and governor belt were found to be O. K.

June 2 the bursting of a fly-wheel at the Creighton power plant, at Tarentum, Penn., instantly killed the engineer, seriously injured his assistant, and hurt several other employees, besides damaging the plant to quite an extent.

June 10 a 32-foot fly-wheel burst and partly wrecked the Shelbyville (O.) Water and Light Company's plant, besides killing the engineer.

It is noticeable that, in none of the above instances was there provided an extraneous safety-stop system.

Engineering Courses at Columbia

Columbia University, New York City, announces an innovation this summer in the form of courses in civil and mechanical engineering, in connection with its summer session from July 9 to August 17, inclusive. This is the first time engineering subjects have been offered at Columbia in summer. The courses cover hydraulics, concrete-steel structures, gas engines and experimental engineering. They are intended for instructors in engineering schools and for technical graduates. Prof. Charles E. Lucke will have charge of the mechanical-engineering section.

The University of Illinois, of Urbana, Ill., is directing attention to its courses in railway engineering and administration, by sending out copies of its bulletin No. 8, which contains detailed information of these courses, of which there are four—railway civil, electrical and mechanical engineering and railway administration.

Business Items

The Bickford & Francis Belting Company has removed to new and larger quarters at 35 Pearl street, Buffalo, N. Y.

The Buffalo Forge Company has changed its Pittsburg office from 1101 Diamond Bank building to 613 House building. E. P. Leadbetter, manager.

The D. T. Williams Valve Company, of Cincinnati, has opened an eastern branch office in charge of Charles K. Thomas, eastern sales agent, at 26 Cortlandt street, New York city.

The York Engineering Company, York, Penn., maker of pipe fittings, recently removed into its new plant, which was made necessary on account of greatly increased business.

The Edison Illuminating Company, Detroit, has installed in the Beecher avenue sub-station a 25-ton electric Northern crane, manufactured by the Northern Engineering Works, Detroit, Mich.

The Uehling gas composimeter, which was described in June POWER, is made by the Uehling Composimeter Company, of Passaic, N. J. The address was inadvertently omitted in the description.

John Sherry, formerly with the Sterling Lubricator Company, has been made general manager of the Standard Force Feed Lubricator Company, with offices at 42 North Water street, Rochester, N. Y.

The Phœnix Tool and Valve Company, 131 Beale street, San Francisco, Cal., has been appointed western agent for the Sight Feed Oil Pump Company, of Milwaukee, and will handle its line of automatic, sight-feed oil pumps and oilers.

The Liverpool office of E. H. Kellogg & Co., whose main office is located at 243 South street, New York, advises that the London & North Western Railroad Company has used more than ten thousand casks of Kellogg's "Anti-Corrosive" cylinder-oil.

The Goubert Manufacturing Company, maker of the Goubert feed-water heaters and Stratton steam separators, recently removed its offices from 85 Liberty street to the new West street building, corner of Cedar and West streets, New York city.

The Catlin Electric Company, operated for the production of electric light and power by the municipality of Catlin, Ill., is a new venture, and its superintendent, V. R. Eades, would welcome catalogs and literature relating to supplies for such a station.

Fourteen White Star continuous oiling systems, which mechanically keep engine bearings supplied with a steady stream of pure lubricating oil, have recently been installed in various power plants by the Pittsburgh Gage and Supply Company, Pittsburg, Penn.

At a special meeting of the directors of the Joseph Dixon Crucible Company, held May 31, to take action on the death of vice-President and Treasurer John A. Walker, George T. Smith was elected vice-president, George E. Long treasurer, and Harry Dailey director and secretary.

E. O. Williams has removed his office and warehouse to 145 and 147 South Clinton street, Chicago, Ill., where with a four-story double building he will be enabled to carry on hand a much larger stock of second-hand engines, boilers, pumps and other power-plant equipment.

Among recent orders for generating sets placed with the B. F. Sturtevant Company, of Boston, Mass., are the following: American Can Company, Indianapolis, Ind.; Brighton Realty Company, Long Branch, N. J., and Lake Superior Iron and Chemical Company, Marquette, Mich.

The Direct Separator Company, of Syracuse, N. Y., recently arranged with Edward P. Brock & Co., 104 High street, Boston, Mass., for the sale of its steam and oil separators and exhaust heads in the New England States. The Direct Separator Company is very busy, and is enlarging its shops.

The Hall Manufacturing Company has removed its works to Harrison, N. J., where it has erected a two-story cement-block building, 80x33 feet. Owing to the increased demands for its oil filters, oil cups, lubricating systems and other lubricating specialties, the company was compelled to build this new plant.

The Loew Manufacturing Company, Cleveland, Ohio, in addition to its large line of power-plant specialties, makes the Loew pipe-threading machine for both hand and machine power. Various types of this machine are illustrated and described in a neat booklet, just issued, which will be sent to any one interested.

The northern Engineering Works, Detroit, Mich., recently shipped to the Denver & Rio Grande Railroad Company, a second 3-motor electric traveling, 15-ton Northern crane of special construction, for use in the round-house. The crane uses alternating-current equipment, and is designed to run on an overhead curved track.

The Ridgway Dynamo and Engine Company, Ridgway, Penn., builders of the McEwen engine and the Thompson-Ryan dynamo, has appointed Samuel W. Hay's Sons, 302 Farmer's Bank building, as its Pittsburg sales agent. The territory assigned to this office is the Pittsburg district, southeastern Ohio, and northern West Virginia.

The Ohio Injector Company, Wadsworth, Ohio, has its large 72-page catalog for 1907, ready for distribution. This handsome edition illustrates and describes a complete line of injectors, ejectors, lubricators, steam specialties and oiling devices for all classes of service, and a copy will be mailed free to any engineer interested in devices of this class.

The Boston Elevated Railway Company, Lincoln power station, Boston, Mass., and the Wood Worsted Mills, Lawrence, Mass., have recently placed repeat orders with the B. F. Sturtevant Company, of Boston, Mass., for its new metal-to-metal fuel economizers. In the case of the Boston Elevated Railway Company, a special form has been adopted to meet special requirements.

The Boston branch of the American Manufacturing Company, maker of America transmission rope and manila, sisal and jute cordage, has outgrown its original quarters in the Postoffice Square building, Boston, Mass., and taken larger offices in the Ames building. W. F. Morgan, previously engineer of the transmission rope department of the company, is manager of the Boston office.

On account of the large number of orders for the Scaife and We-Fu-Go water softening and purifying systems received by Wm. B. Scaife & Sons Company, of Pittsburg, Penn., the company has been obliged to increase its shop capacity for building these systems. An addition to the present shops at the works at Oakmont, Penn., has just been completed, in which special machinery is being installed to increase the output.

One result of the recent annual meeting of the directors and stockholders of the Ridgway Dynamo and Engine Company, of Ridgway, Penn., was the reorganization of the sales department. H. A. Otterson, formerly assistant superintendent, has been made sales manager, with R. C. Eccleston as his assistant. In addition to the usual work, the

control of all agencies and the advertising has been placed in this department.

The Power Specialty Company, 111 Broadway, New York, reports recent sales of 120 Foster superheaters, aggregating 42,000 horse-power. These superheaters are to be installed in Babcock & Wilcox, Stirling, Edge Moor, Heine, Franklin, Atlas and other boilers, including a number of return-tubular boilers. The above include a large number of repeat orders following the successful operation for from one to five years of initial installations.

W. E. Richardson has resigned as general superintendent of erection for the Westinghouse Machine Company, to take active charge of the Sight Feed Oil Pump Company's business at Milwaukee, Wis. Mr. Richardson, who is president of this company and inventor of the oil pumps it manufactures, was for sixteen years in the employ of the Allis-Chalmers Company, and has for the past two years been with the Westinghouse company.

The Locke Regulator Company, Salem, Mass., reports that it has received a letter from the Casualty Company of America to the effect that the Locke engine-stop meets with its approval and that it will offer to any customers using Locke engine-stops a discount of 20 per cent. on both employers' liability and fly-wheel rates. The Locke Company also reports that owing to the frequency of fly-wheel explosions of late that its engine stop business has received quite a boom.

George B. Foster, who was formerly in charge of the Wagner-Bullock sales agency in Chicago, and recently the assistant sales manager of the Allis-Chalmers Company, is now connected with the Power Improvement Company, of Milwaukee, at the Chicago office, Fisher building. The Power Improvement Company, being industrial and commercial engineers, is prepared to take contracts for power plants of any capacity, also making a specialty of industrial and water-works installations.

The Burt Manufacturing Company, Akron, Ohio, maker of the Burt, Cross, American and Warden oil filters, Burt oil filtering systems, Burt and Standard exhaust heads, and the Burt combination skylight and ventilator, is enjoying a season of unusual activity in filling new and repeat orders for these products. The company has just issued a very handsome catalog, 6x9 inches, 79 pages, illustrating and describing the lines mentioned, a copy of which will be sent to any of our readers on application.

A great reduction in the price of Reagan grates has been announced by the Reagan Grate Bar Company, 211 No. Front street, Philadelphia, Penn. This company has perfected a system whereby the Reagan grate can now be installed by any competent engineer, all parts being carefully marked and accompanied by special blueprints showing the method of installation, which saves the Reagan company the cost of sending men to all sections of the country to install them. The grates are guaranteed to be the standard Reagan product.

The Trill Indicator Company, Corry, Penn., is distributing a book about its indicators, reducing wheels and planimeters, which contains much useful and handy information about taking and reading indicator diagrams. It shows in detail how to tap the cylinder, make pipe connections, place the indicator, connect it with the crosshead, adjust the tension, etc. The indicator diagram for a single-cylinder engine is carefully analyzed and rules given for finding the horse-power. Characteristic diagrams from engines of various types, including faulty diagrams, are analyzed and suggestions made for their correction.

The Liberty Manufacturing Company, Pittsburg, Penn., has just issued Bulletins Nos. 18 and 25. No. 18 describes the Liberty heavy-duty turbine cleaner, which is of all-steel construction, and of unlimited power and capacity. It will, it is stated, remove scale of any thickness quickly and cheaply. It requires but one man to operate and is guaranteed not to injure the tubes. No. 25 describes the pneumatic tube cleaner, an appliance which, it is claimed, has extreme power and is most effective in heavy scale. As its name indicates, it is operated by air pressure and is for use where the water supply is limited.

The Stone & Webster Engineering Corporation has recently placed contracts for new equipment for the Pawtucket Electric Company, including four 520 horse-power Babcock & Wilcox boilers equipped with Foster superheaters for 150 degrees superheat. This boiler-room equipment is practically a duplicate of that recently ordered by the Texas Traction Company, of which the Fred A. Jones Company, of Houston, is consulting engineer, for operating the Curtis turbines in the new power station at McKinney, Texas. The Virginia Passenger and Power Company, of Richmond, has also recently placed an order for Allis-Chalmers turbines and Babcock & Wilcox boilers equipped with Foster superheaters for 175 degrees.

Mechanical-draft apparatus is to be furnished by the B. F. Sturtevant Company, of Boston, Mass., for boilers in the following power plants: Pennsylvania, Fort Wayne & Chicago Railway, Allegheny, Penn.; Acushnet Mills, New Bedford, Mass.; State Hospital for the Insane, Howard, R. I.; Syracuse Malleable Iron Works, Syracuse, N. Y.; Union Light, Heat and Power Company, Fargo, N. D.; the Fisheries Company, Fall River, Mass.; Wood Worsted Mills, Lawrence, Mass.; El Paso Electric Railway Company, El Paso, Texas; Russia Cement Company, Anocortes, Wash., and the Hazard Manufacturing Company, Wilkes-Barre, Penn.

The Canton-Hughes Pump Company, of Canton, Ohio, has recently constructed large pumps for the Union Salt Company, Cleveland, Ohio, the Columbia Chemical Company, Barberton, Ohio, the Mitchell Engineering and Machinery Company, Butte, Mont., and the American Car and Foundry Company, Terre Haute, Ind., and also secured a contract for a high-duty pumping engine from the village council of Cassapolis, Mich. The export trade of this company has also been large. Shipments have recently been made to New Zealand, Australia, Japan, China, India, Belgium, Sweden, Canada, Mexico, etc. The erection of a pattern room, 40x100 feet, is made necessary by the increase of business.

The Oji Paper Company, of Tokio, Japan, has placed orders in the United States for a complete electrical and mechanical equipment for its new mills, which will be operated by electric drive. In addition to the motor equipment of the paper-making machinery, the installation will include a new hydroelectric plant, with a 15-mile transmission line and sub-station. The electrical equipment will be furnished by the General Electric Company and will include the following: Four three-phase, 60-cycle, 312-kilovolt-ampere units, two 150-kilowatt exciter generators, twelve water-cooled step-up transformers, twelve step-down transformers, an eight-panel switchboard, five 750-horse-power 2000-volt induction motors, four 350-horse-power induction motors, and one 200-horse-power induction motor.

The Du Bois Iron Works, Du Bois, Penn., builders of gas engines and pumping machinery, recently appointed several representatives to handle the business in various sections of the country, as follows: Aumen Machinery and Supply Company, 324 N. Holliday street, Baltimore, Md.; John H. Seibert, 116 to 120 Washington street, Reading, Penn.; Peerless Belting Company, 76 and 78 Main street, Buffalo, N. Y.; F. H. Brown Machinery Company, Park building, Pittsburg, Penn.; Scranton Supply and Machinery Company, 131 Wyoming avenue, Scranton, Penn.; W. M. Metz, Gap Mills, Va.; Charles Willemsen, 810 N. 6th street, St. Louis, Mo. At Baltimore, Reading, Scranton, Pittsburg and Buffalo a line of engines will be carried for exhibition purposes and for demonstrating to purchasers. The company also appointed as special representative, H. J. McCormac, who will travel from the head office and works at DuBois, Penn.

New Equipment

Thayer P. Gates, Chapel street, Saylesville, R. I., is in the market for a gas engine.

The Berkeley (Cal.) Electric Lighting Company will erect a new $150,000 substation.

Plans are being considered for the erection of a municipal electric light plant in Hancock, Mich.

The Tacoma (Wash) Gas Light Company, it is said, will expend about $75,000 in improvements.

The Peoples' Power Company, Moline, Ill., is planning to make improvements, expending about $250,000.

It is stated that the Freeport (Ill.) Railway, Light and Power Company will erect a new power plant.

The Union Stock Yards and Transit Company, Chicago, Ill., will put up a model power plant, to cost $250,000.

Plans have been prepared by C. R. Mead, Dayton, Ohio, for improvements at the municipal electric light plant in Richmond, Ind.

The Citizens' Electric Light, Heat and Power Company, Altoona, Penn., is reported to have decided to make improvements at its plant.

The Singer Manufacturing Company, Bridgeport, Conn., is having a central power plant built which will generate 2000 horse-power.

The city of Seminary, Wis., has voted the issuance of $10,000 bonds for water works and other public improvements Address the Mayor.

The installation of a 300-horse-power engine in the municipal electric water and lighting plant at Paris, Tenn., is being considered.

The Howard & Bullough Company, Attleboro, Mass., is remodeling its power plant and will substitute gas engines for steam engines.

It is reported that the American River Electric Company, of Stockton, Cal., will construct an auxiliary electric plant at a cost of $250,000.

The Hillsboro (Texas) Gas and Electric Company is making plancs to install a 75-kilowatt alternator and four transformers in its plant.

The Howard Electric Light Company, Junction City, Ore., is considering the installation of a large turbo-generator set and an additional boiler.

A company is being formed at Bryson City, N. C., for the purpose of establishing an electric-light plant. J. L. Gibson, of that place, is interested.

Bids are being received for the rebuilding of the power house of the San Francisco (Cal.) Gas and Electric Company, recently destroyed by fire.

The Suburban Electric Light Company, Scranton, Pa., is making extensive improvements. It is said the company plans to spend $1,250,000.

Plans are being considered by the electric and water board at Lansing, Mich., for increasing the capacity of the municipal electric-lighting plant.

It is reported that plans have been completed for the construction of a power house for the Scranton (Pa.) Electric Light and Heating Company.

The citizens of Salamanca, N. Y., have voted to issue $20,000 for water-works improvements and $5000 for improvements to electric-light plant.

The Houston (Texas) Lighting and Power Company contemplates the installation of a 1500-kilowatt turbo-generator set, with boilers, condenser, etc.

The Worcester Salt Company, Silver Springs, N. Y., is planning to install in the boiler room an overhead coal bunker and coal-handling machinery.

The Union Gas and Electric Company, of Cincinnati, is completing plans for a 100,000 horse-power station at Columbia, a suburb of Cincinnati. The initial installation will consist of four Curtis turbine units of 8000 kilowatts capacity each. The station will be on the Ohio river, with both water and railroad transportation for coal and materials.

New Catalogs

W. J. Ellis, Box 26, Colwyn, Pa. Circular. Metallic packing. Illustrated.

Buffalo Forge Company, Buffalo, N. Y. Folder. Disk wheels. Illustrated.

Richard J. Flinn, West Roxbury, Mass. Circular. Steam trap. Illustrated.

Sterling Lubricator Company, Rochester, N. Y. Catalog. Lubricators. Illustrated, 32 pages, 4x6½ inches.

Pratt & Whitney Company, Hartford, Conn. Catalog No. 4. Small tools. Illustrated, 216 pages, 4½x7½ inches.

Buckeye Engine Company, Salem, Ohio. Booklet. The A B C of Blue Printing. Illustrated, 4x6½ inches.

E. M. Carr Pump Governor Company, New Castle, Ind. Circulars. Steam pump and oil pump governors. Illustrated.

The Smith Gas Power Company, Lexington, Ohio. Catalog. Suction gas producer. Illustrated, 32 pages, 6x9 inches.

The Lunkenheimer Company, Cincinnati, Ohio. Booklet. Generator valves. Illustrated, 24 pages, 3½x6 inches.

Bates Machine Company, Joliet, Ill. Catalog. Vertical automatic high speed engines. Illustrated, 36 pages, 6x9 inches.

The D. T. Williams Valve Company, Cincinnati, Ohio. Booklet. Oil and grease cups. Illustrated, 19 pages, 3½x6 inches.

Detroit Stoker and Foundry Company, Detroit, Mich. Catalog. Automatic stokers. Illustrated, 32 pages, 6½x10 inches.

B. F. Sturtevant Company, Hyde Park, Mass. Bulletin No. 146. Electric propeller fans. Illustrated, 7 pages, 6x9 inches.

O. K. Oil Filter Company, 2917 Woodland avenue, Kansas City, Mo. Catalog. Oil filters. Illustrated, 22 pages, 5x7 inches.

Buffalo Forge Company, Buffalo, N. Y. Folder. Buffalo steel plate planing mill exhausters and dust separators. Illustrated.

Burt Manufacturing Company, Akron, Ohio. Catalog. Oil filters, exhaust heads and ventilators. Illustrated, 80 pages, 6x9 inches.

Jeffrey Manufacturing Company, Columbus, Ohio. Catalog, No. 57B. Conveying machinery for saw mills, lumber mills and wood-working industries. Illustrated, 72 pages, 6x9 inches.

Help Wanted

Advertisements under this head are inserted for 50 cents per line. About six words make a line.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," Box 248, POWER.

WANTED—Salesman familiar with steam boiler practice; also young man in drafting room to develop into salesman. Parker Boiler Co., Philadelphia, Pa.

Situations Wanted

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

A POWER HOUSE chief engineer of wide experience wishes to make a change, preferably outside of Greater New York. Box 252, POWER.

ERECTING ENGINEER, reciprocating engines or steam turbines, wishes position with a house that can use a live man. Box 253, POWER.

WANTED—Position as stationary engineer; have a second-class certificate and seven years' experience; am also a machinist. Box 251, POWER.

POSITION WANTED by young man (25), with six years' experience erecting and repair work, steam fitting, hoisting engineer. Box 257, POWER.

A MAN WITH experience as superintendent, master mechanic and chief engineer is open for a position with mill, factory or power company. Box 254, POWER.

WANTED—Position as chief engineer or master mechanic; understand piping, steam fitting, electrical appliances and handling of men; can furnish best recommendations of work and charcter. Box 256, POWER.

CHIEF ENGINEER, accustomed to the operation of large industrial, electrical, power plants, and capable of producing results, would like to connect with a concern which desires a first-class man. Box 249, POWER.

WANTED—Position as master mechanic for coal mines; experienced in up-to-date mining, compressed air and electric haulage, mining machines, etc.; 28 years old, single, will go anywhere; prefer warm climate; can speak Spanish. Box 255, POWER.

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Adjusting the Sturtevant Compound Engine

Directions for Setting Valves and Adjusting the Governor and Drainage Systems of the Vertical Cross-compound Type

BY CARL S. DOW

The setting of the valves and the adjustment of the governor and drainage systems of any make of engine may well be preceded by a very brief description of its leading characteristics. As shown by the accompanying sectional view, Fig. 1, the engine in question is of the vertical cross-compound type, with the cranks at 180 degrees.

The high-pressure cylinder has a balanced piston valve working in a removable bushing which contains the ports; it takes steam on the inside and exhausts at the ends; auxiliary ports in the valve (see Fig. 9) increase the port opening, during the admission period, preventing wire-drawing. The piston valve is controlled by an inertia governor which is a modification of the Rites type, therefore the cut-off in the high-pressure cylinder is automatically changed according to the load.

The low-pressure slide valve is balanced by means of a back platen maintained in position by six springs, three of which are shown at *A*, *B* and *C*, Fig. 2. These springs fit the holes *D*, *E* and *F* in the valve-chest cover. The low-pressure valve is not connected to the governor, and as the angular advance is constant, the cut-off in this cylinder does not vary with the load, but is fixed. However, the low-pressure eccentric is adjustable; that is, the throw may be changed by the engineer while the engine is not running. The adjustable eccentric permits changing the lead and cut-off, for altering the valve travel alters these events. The low-pressure cut-off occurs at practically one-half stroke for normal load.

It is well to set the low-pressure valve first, for this operation is much easier than in the case of the high-pressure side. It is first necessary to remove the tap-bolts and take off the covers leading to the low-pressure valve chest, the crank-case, the valve-rod guide and the eccentric; these are shown at *A*, *B* and *C*, Fig. 3, and at *D*, Fig. 6. The low-pressure crank-pin should be put on the top center, following any of the approved methods. A simple operation which quickly gives the position with sufficient accuracy for preliminary valve setting is to turn the governor wheel by means of the bar until the face *A*, Fig. 4, of the connecting-rod is parallel to the front surfaces *B B* of the crank-arms.

The throw of the low-pressure eccentric should now be adjusted, the angular advance having been fixed when the key-way was cut in the eccentric hanger which is shown in Fig. 5. But before this can be done the direction of rotation must be determined. As the observer is now facing the low-pressure end, the engine is running under if turning clockwise. If the engine is to run in this direction (under), move the eccentric, which is fulcrumed to its hanger at *F*, and fasten the pin *P* at the extreme left-hand end of the slot *S*. This gives the eccentric maximum throw and the valve full travel. Of course the pin *P* should be fastened at the other end of the slot if the engine is to run over. When the pin *P* is in the center of the slot, as shown in Fig. 5, the valve has minimum travel and no lead, because the lead decreases as the pin approaches the center of the slot, for this operation decreases the valve travel.

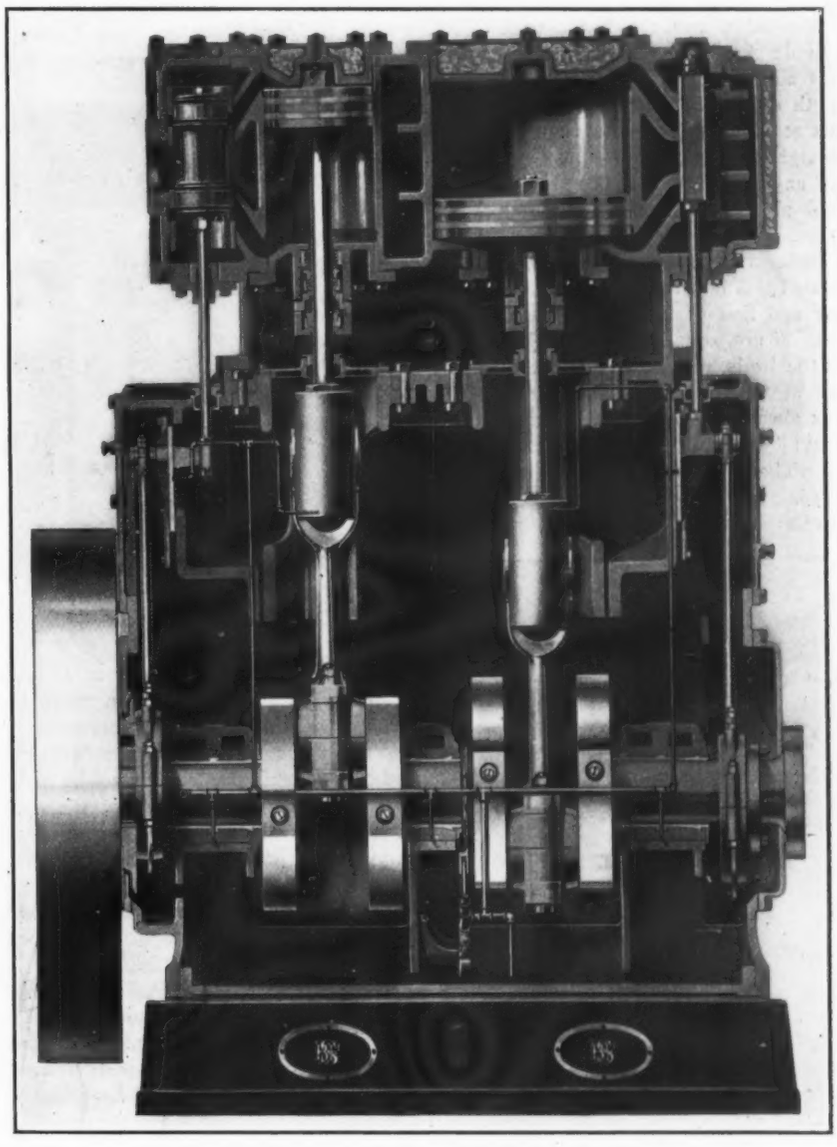

FIG. 1. SECTION THROUGH CYLINDERS AND VALVES

With the eccentric fixed for full throw and the low-pressure crank-pin on the top center, adjust the slide valve for a lead of 3/32 inch at the top, that is, the

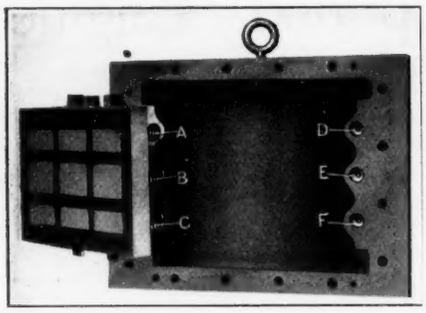

FIG. 2. BACK PLATEN OF LOW-PRESSURE VALVE

narrow opening between the top edge Y of the valve and the lower edge X of the port should be 3/32 inch. See Fig. 3. This adjustment is made by altering the length of the valve rod by means of the nuts at N. Both these nuts are shown at the right-hand side of the large section of the engine, Fig. 1. The low-pressure crank-pin should now be put on bottom center. The lead at the bottom should be ¼ inch, or, as shown in Fig. 6, the distance (MN) between the edge of the port and that of the valve should be ¼ inch. If not, equalize the error by changing the leads, making one-half the difference at the top and one-half at the bottom; always remembering that the bottom should have a little more lead than the top. The low-pressure side is now adjusted.

Before setting the high-pressure valve

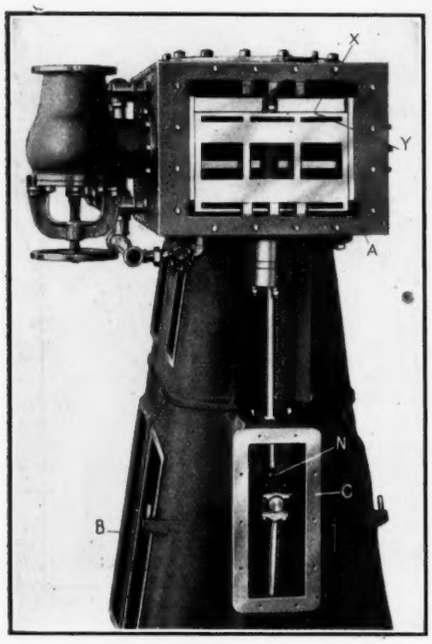

FIG. 3. LOW-PRESSURE VALVE SIDE SHOWING LEAD ON TOP END

the governor must be considered. The general appearance of this form of inertia governor is shown in Figs. 7 and 8, the former being a view of the side next the engine. The eccentric is not keyed to the shaft, but is free to move across it because of the slot, thus changing the angular advance and consequently the cut-off. The eccentric and weight arm of the governor are both rigidly fastened to a stud S, which passes through the hub of the governor wheel; the eccentric is thus compelled to move with the weight arm and its position varies as the stud moves nearer or farther away from the shaft center, due to inertia and centrifugal force. The disk D, Fig. 7, is the oil guard and has nothing to do with the action of the eccentric. When the governor wheel is stationary the tension of the spring is such as to allow the weight M to rest against the stop T, Fig. 8, in which position the valve has maximum travel and maximum lead.

To Set the High-pressure Valve

To set the high-pressure valve the valve

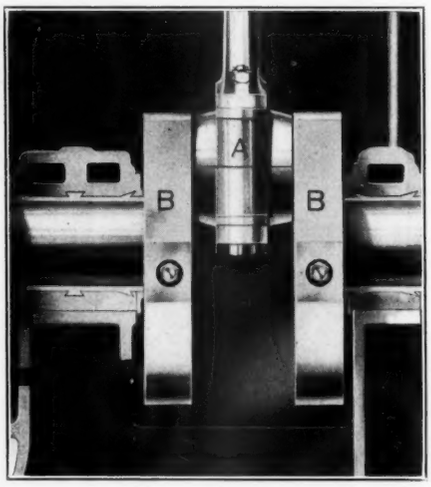

FIG. 4. AN EASY METHOD OF PUTTING THE ENGINE ON CENTER

plug V, Fig. 8, and the cover at D must be removed. With the piston valve enveloped by its bushing, it is impossible to see the valve itself, except at the top, and consequently the lead cannot be measured directly as in the case of the plain slide valve. The setting is accomplished by measuring the distance from the top of the valve to a given surface, which in this engine is the top of the valve chest with the plug or cover removed. The reference edge is shown at T, Fig. 9.

Since the piston valve takes steam on the inside, the inside edges of the ports in the bushing are the important ones. Evidently the lead is the distance the inner edge of the valve has moved from the inside edge of the port when the crank is on the center; therefore when the valve is properly set the measurements must show that the desired lead exists in the valve chamber.

The high-pressure crank should be placed on the top center. The lower edge of the upper port is 5 15/16 inches below the top surface T of the valve chamber. Since the thickness of the valve, measured from its top surface to the steam edge, is 2 7/16 inches, the top of the valve should be 3¼ inches from the reference edge T, to give a lead of ¼ inch. This

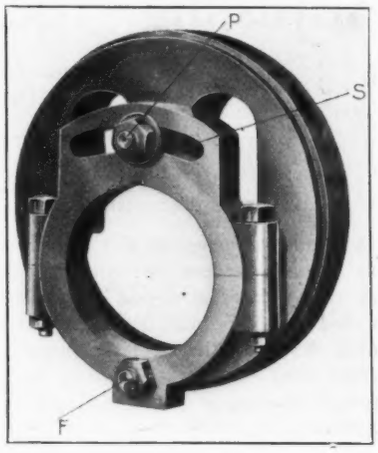

FIG. 5. ADJUSTABLE LOW-PRESSURE ECCENTRIC

may be shown as follows: 5 15/16 — 2 7/16 — ¼ = 3¼. It is well to remember in this connection that the valve rises to open, hence the lead (¼ inch) is subtracted from the distance of the top of the valve to the edge T (see Fig. 9).

To set the valve, then, it is only necessary to put the high-pressure crank on the top center and adjust the length of the

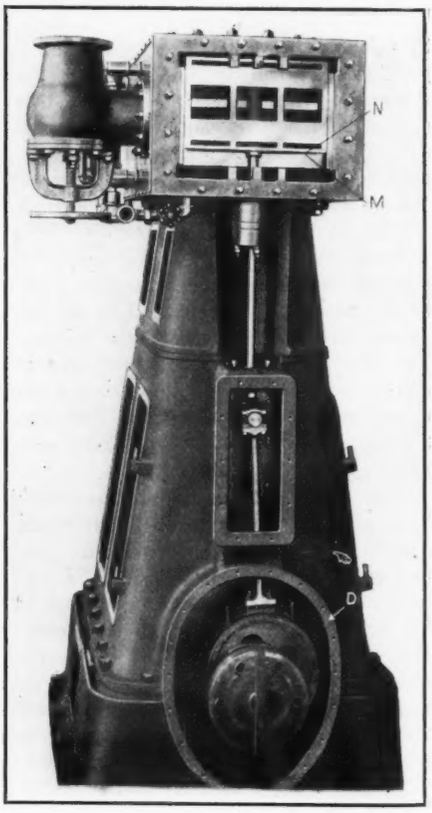

FIG. 6. LOW-PRESSURE VALVE SIDE SHOWING LEAD ON BOTTOM END

valve stem to make the top of the valve 3¼ inches from the top of the valve chamber. As in the case of the low-pressure valve, the stem is lengthened or

shortened by means of the nuts on the stem at the slide.

It is not necessary to determine the lead at the bottom, because the valve and its

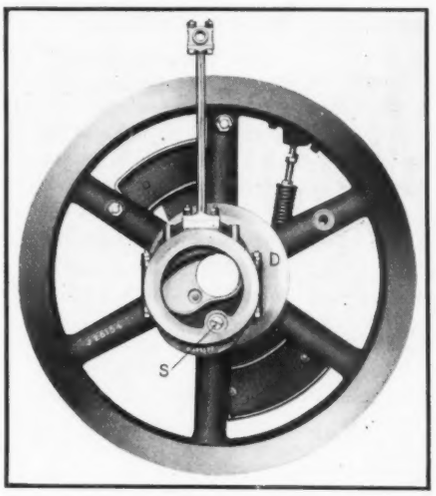

FIG. 7. THE INERTIA GOVERNOR

bushing are designed to give proper lead at the bottom when the top lead is ¼ inch. The same method of measuring is followed, the only difference being due to the location of the lower port.

After replacing the covers and connecting the cylinder drains to the sewer, if the engine is to run non-condensing, or to the exhaust pipe if condensing, the start may be made. The reason for connecting

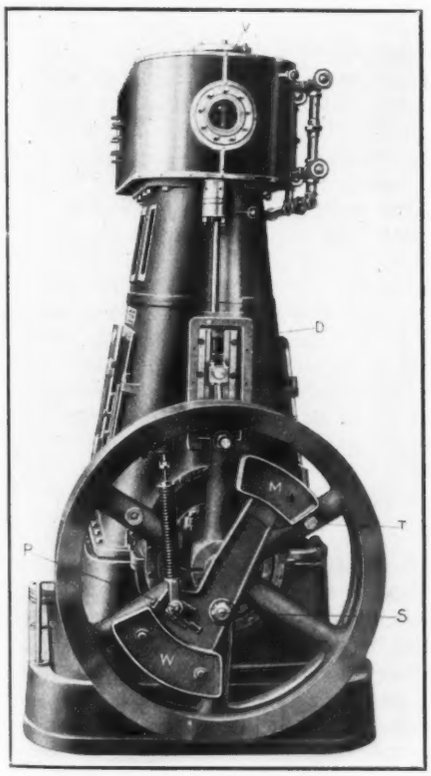

FIG. 8. THE GOVERNOR IN POSITION

cylinder drains to the exhaust pipe instead of to the sewer, or letting the drip go to the atmosphere, is that a vacuum cannot be maintained if the cylinder is thus placed in communication with atmospheric pressure.

In the Sturtevant compound engine there are two drainage systems: one for the cylinders, as briefly mentioned above, and another for draining water of condensation from the stuffing-boxes. As shown in Fig. 1, small pipes connect with the depressions at the valve-rod and watershed partition stuffing-boxes. The condensation collecting at these points is led through the piping, which is wholly within the inclosing frame, and delivered to the sewer. The rest of the piping within the frame is the system of forced lubrication, by which all bearings and sliding surfaces are supplied automatically with lubricant.

To start the engine, if condensing, the

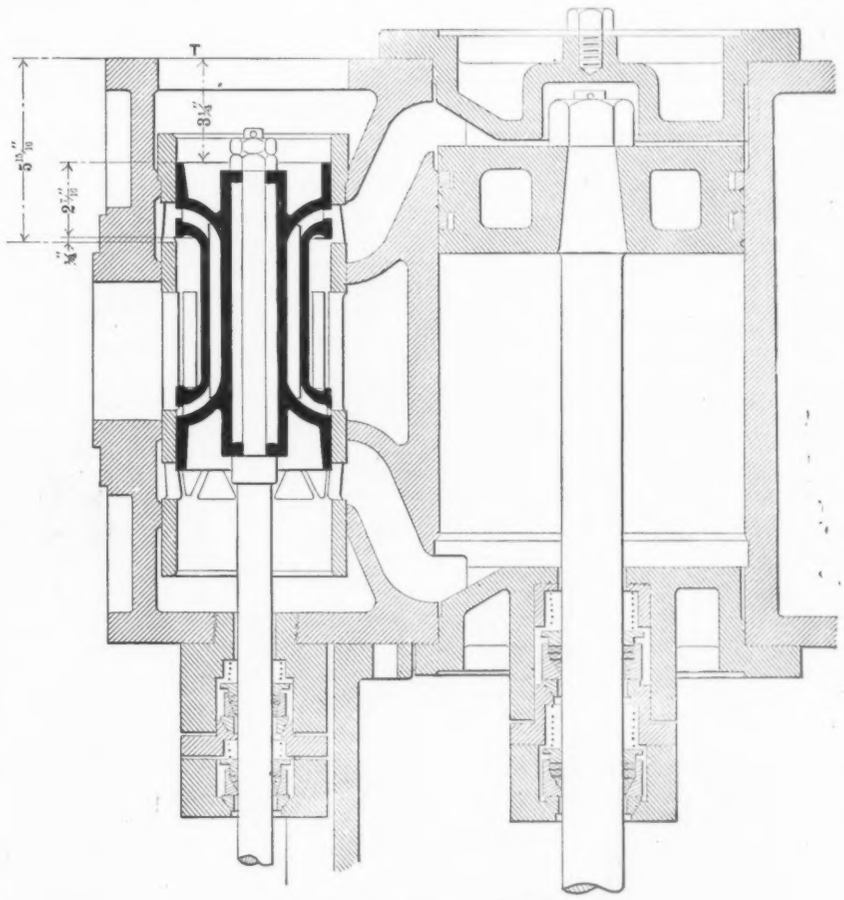

FIG. 9. THE HIGH-PRESSURE VALVE

air and circulating pumps are first put into operation so that a partial vacuum will be created in the condenser. Meanwhile, a little steam should be allowed to warm the cylinders, the condensation leaving by the cylinder drainage system.

As soon as convenient the indicator should be attached, for the valve setting is not yet final. Fig. 10 shows the indicator rig. The indicators are located at the three-way cocks *A* and *B*, which allow steam to enter the indicators from the two ends of the cylinders. The reducing motion consists of a rod *R*, moving vertically in a projection on the door, and a rocker *K*, which transmits the crosshead motion to the rod *R*, the free end *D* of the rocker engaging the rod *R* at *C*. As shown at the right-hand side of Fig. 10, the rod *R* is directly below the indicator cord.

When a moderate speed has been attained, diagrams should be taken simultaneously from the cylinders and carefully examined for defects in valve setting. The adjustments to be made depend, of course, upon the faults revealed, but usually slight adjustments in the lengths of the valve stems will be sufficient. For instance, suppose the top of the high-pressure cylinder is developing more power than the bottom, the card areas may be made nearly equal by shortening the high-pressure valve stem which will bring cut-off earlier at the top and later at the bottom; the leads will change but little, that at the top decreasing, and that at the bottom increasing. The same principles apply to the low-pressure side, but in general the low-pressure valve will give satisfactory distribution if it was carefully set during erection and the high-pressure valve is properly adjusted.

Adjusting the Governor

The only remaining adjustments are those pertaining to the governor. As already stated, this engine is regulated by a modified form of the Rites inertia governor, which has been so universally adopted for high-speed engines that a de-

scription is unnecessary, especially as it is ably discussed in the November (1906) POWER. It is well, however, to bear in mind a few of its fundamental principles, for governor adjustments call for a knowledge of these principles rather than a blind following of directions for changing certain adjustments because of certain defects.

The governor combines both the centrifugal and inertia effects: the former controlling the speed variations caused by changes of load, while the latter has to do with steadiness. The governor arm tends to maintain its rotative speed due to the inertia of the heavy weights. If the load increases, the engine tends to slow down, that is, the rim of the governor wheel will slow down but the weights tend to move at the same speed as before. The effect of these two movements is that the center of gravity of the arm moves inward, increasing the load and lengthening the cut off.

ward. If on increase of load, the speed drops more than it should, the spring pin *P* (Fig. 8) may be set nearer the governor arm pivot by moving it along the slot, or the weight at *W* may be reduced, and also the tension in the spring. In short, speed regulation consists primarily in balancing the spring tension against the centrifugal force of the arm. Exact balance at all points in its movement would result in practically uniform speed from no load to full load, but the governor would then lack stability, hence it is better to not quite balance the centrifugal force, so that the speed will drop about 2 per cent. with an increase from no load to full load.

DETAILS AND MEASUREMENTS OF STURTEVANT COMPOUND ENGINES.

SIZE OF ENGINE.	HIGH PRESSURE VALVE.									LOW PRESSURE VALVE.						
		LAPS.				LEADS.					LAPS.				LEADS.	
	Maximum Valve Travel.	Steam Top.	Steam Bottom.	Exhaust Top.	Exhaust Bottom.	Top.	Bottom.	Thickness of Valve from Top to Steam Edge.	Top of Valve to Top of Chest Valve set with Lead.	Top of Chest to Bottom Edge of Top Port.	Maximum Valve Travel.	Steam Top.	Steam Bottom.	Exhaust Top.	Exhaust Bottom.	Top.	Bottom.
6¼ — 10⅛ × 6¼	2⅛	11/16	11/16	0	1/16	5/32	5/32	1⅝	2 11/32	4⅛	2⅛	11/16	11/16	0	7/32	1/16	5/32
*7 — 12 × 7	2½	7/8	7/8	..	..	..	..	....	....	....	2½	..	..	..	..	..	..
8 — 14 × 8	3 1/16	7/8	7/8	3/32	1/4	1/16	1/16	2 5/32	2⅞	5 1/32	3⅜	1 3/32	1 3/32	0	1/4	1/16	3/32
10 — 18 × 10	4⅜	1⅛	1⅛	1/16	1/4	1/4	1/4	2 7/16	3¼	5 1/16	4⅜	1½	1⅜	0	1/32	3/32	1/4

*Valves being re-designed.

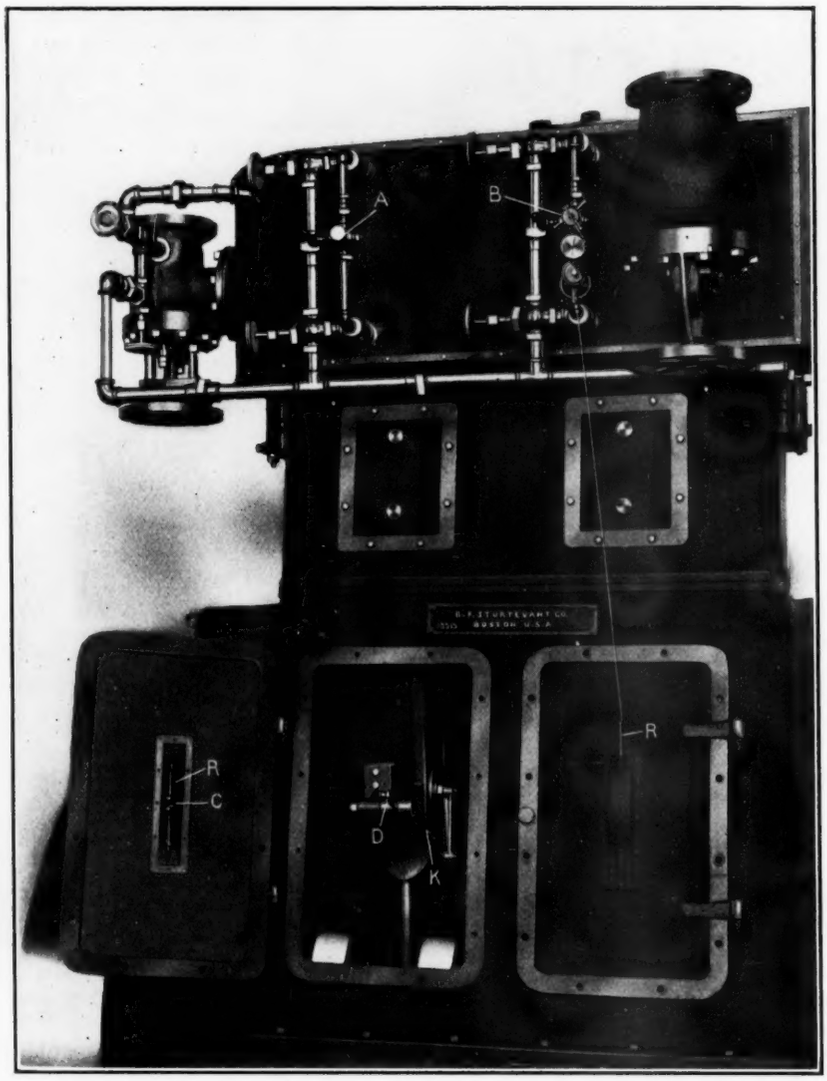

FIG. 10. THE INDICATOR RIG. THE CORD SHOULD HAVE BEEN SHOWN LEADING STRAIGHT OFF FROM THE PIN R

If while the load changes slightly the speed is steady, but lower than desired, the tension of the governor spring may be increased, or the spring pin *P* moved out-

If the governor is unsteady, and requires several long swings of the arm to correct the speed, weight may be added to the long end of the arm (*M*, Fig. 8), or the spring pin *P* may be moved outward in its slot.

These brief remarks regarding the governor are for testing plate adjustments, but it is assumed that the valves are correctly designed, the pins of ample size, and properly lubricated. After long service wear may affect the condition of the parts that were all that could be desired when on the testing plate. When in poor condition, governor adjustments may be slightly different, for a worn valve, scored pin, or insufficient lubrication may be the fault of poor speed regulation. A careful perusal of the discussion in the November POWER referred to will greatly assist in locating and remedying defects.

The instructions given for setting the valves refer to the Sturtevant compound engine having cylinders 10 and 18 inches in diameter, and a stroke of 10 inches. This type of engine is built in other sizes, as given in the accompanying table. The various sizes of this class of engine vary in dimensions only, therefore the valves are set in the same manner for all, the measurements differing of course. The above table gives further details and important measurements.

A company has been formed to develop the water power of the Tantramar river, near Sackville, N. B., where the tidal influence of the Bay of Fundy can be used to advantage. It is believed that 75,000 horse-power can be developed. There will be three concrete dams, each 60 feet high and 1000 feet long; the power house will be 800 feet long, 42 feet wide and 60 feet high. The dams will form a reservoir and a discharge basin of equal capacity. Turbines placed in the dams will give power as the reservoir and basin empty and fill.

Producer Gas for Firing Steam Boilers

By A. M. Gow

Within the past few years there has been a very rapid increase in the successful application of producer gas for the purpose of power generation, and the firing of various types of kilns and furnaces. It is to be expected, therefore, that in the minds of many persons has arisen the question: Why should not producer gas be used for firing steam boilers? And many other persons, not content to ask the question, seeing the utility of producer gas in certain places, affirm with confidence that producer gas should be used for firing steam boilers. The purpose of this brief article is to answer the question propounded and expose the fallacy of the affirmation.

To begin with, arguments based on the successful application of gas producers to

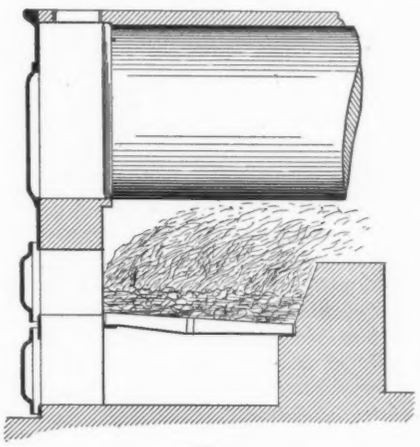

FIG. 1

metallurgical furnaces have little or no bearing upon the question of their successful application to steam boilers. The steam boiler is essentially a vessel containing water, and through its walls must be conducted heat for the conversion of the water into steam. The temperature inside the boiler is rarely over 400 degrees Fahrenheit. Herein a boiler differs fundamentally and radically from any form of furnace or kiln, where heat is directly applied to the material to be heated at a temperature of from 2500 to 3000 degrees. In the case of the boiler the heat is applied by conduction, and the efficiency of the boiler depends wholly and entirely upon what proportion of the heat of the gaseous products of combustion is transmitted to the water. Efficiency is a function of initial and terminal temperatures of the products of combustion regardless of how those gaseous products are obtained. Radiant heat, from a luminous flame, may increase the transmission of heat through those surfaces subject thereto, but the fact that as high efficiency may be obtained with non-luminous coke, as with luminous bituminous coal, is conclusive proof that efficiency does not depend upon luminosity of flame. The heat which the boiler can utilize must exist as sensible heat in the gases derived from the combustion of fuel.

Do the products of combustion from producer gas contain more heat than the products obtained from burning the same fuel direct? It is perfectly evident that if combustion is complete in each case there will be no difference in the amount of heat evolved. But is it reasonable to expect more complete combustion through the use of producer gas than by firing fuel direct?

That complete combustion is not always secured when coal is fired direct will not be denied. The presence of carbonic oxide in the flue gases and an excess of black smoke prove this. But that combustion may be complete is demonstrated in hundreds of coal-fired boiler furnaces where no carbonic oxide is present in the flue gases, and the loss of carbon in smoke is too small to be determined. When this result is accomplished, and it is no great feat of engineering to accomplish it, the gas producer cannot possibly make any gain in the amount of heat evolved. In this connection it is well to remind the gas-producer advocates that the carbon in the blackest of black smoke does not represent a loss of more than 2 per cent. of the carbon content of the fuel.

Whether the boiler is so designed as to heating surface and setting as to absorb the heat in the products of combustion is another question, upon which the gas producer has no bearing. From a given weight of fuel the gas producer can evolve no more heat than the direct-fired furnace. If in some cases it can be shown that a gas producer has made a gain in heat production over a direct-fired furnace it is only evidence that the direct-fired furnace was badly designed or badly handled. A badly designed and badly handled gas producer as compared to a well designed and well handled direct-fired furnace, would have given reverse results.

It is frequently stated that producer gas can be burned with the theoretical quantity of air necessary to supply the oxygen, and that consequently the products of combustion, not being diluted with an excess of nitrogen, are less in volume than when the fuel is burned direct. But the analysis of the products of combustion of producer gas does not bear out this statement. Both in the gas-engine cylinder and the regenerative furnace an excess of air is always required to secure complete combustion. It is true that in boiler practice there may be and frequently is a large loss due to excess of air. This is bad practice. But the same bad practice would involve the same result were producer gas used. Producers do not carry with them a guarantee of good practice, and those who have had extensive experience in operating both gas producers and coal-fired boiler furnaces will agree that it is easier to get good average firemen than it is to get good average gas makers.

The gas-producer enthusiast makes the claim, usually rather vague and undefined as to details, that in practice there may be effected certain economies in fuel handling, maintenance, convenience, etc. A few diagrams will help in the consideration of this claim.

In Fig. 1 is shown a furnace, with a flat grate, as ordinarily used under a horizontal tubular boiler. The thickness of the fire bed on the grate depends upon the character of the fuel, the draft and the skill and diligence of the fireman. Some of the air required for combustion passes through the fuel bed, and some is ad-

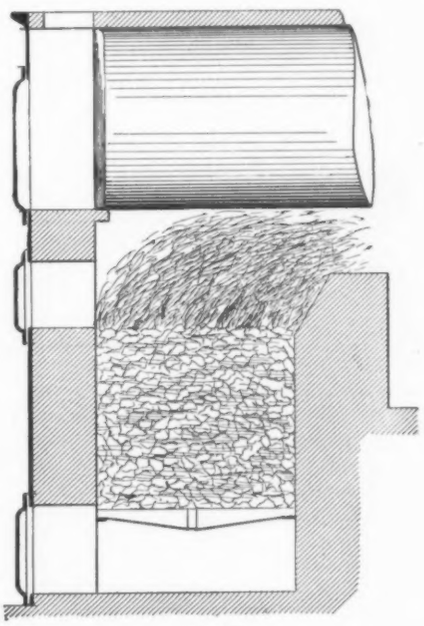

FIG. 2

mitted above the fire through the furnace door. If desired, an infinite variety of mechanical modifications may be introduced, such as shaking grates, air ports in the side walls or the bridge wall, steam jets, etc. These may be good, bad or indifferent. Suffice it to say that with this setting complete combustion of the fuel is secured in thousands of existing plants. It is low in first cost and maintenance, accessible for repair, and can be operated by labor with little skill or training.

Now, change Fig. 1 to a gas producer, as shown in Fig. 2. The top of the fuel bed remains upon the same level, but instead of a few inches of fuel on the bars there must be carried not less than three feet. In order to make gas, half the quantity of air required for complete combustion is now admitted through the grates and half through the fire doors, or other apertures above the fuel, to consume the gas made. By what line of reasoning can it be maintained that the arrangement in Fig. 2 affords economies in operation over that shown in Fig. 1?

Evidently Fig. 2 does not show a workable arrangement at all, for the three-foot fuel bed is inaccessible, and cannot be barred down. Consequently, we come to Fig. 3, where the producer offsets the boiler setting that the fuel bed may be accessible from the top. In this connection it is well to bear in mind that in good gas-producer practice the consumption of fuel per square foot of grate area is about one-half that obtainable in good practice upon a flat grate. In consequence, the cross-section of the producer must be considerably greater than the grate area of an equivalent boiler furnace.

In Fig. 1 there will be certain repairs to make upon the furnace walls; Fig. 3 has several times as much furnace-wall area. In Fig. 1 there are losses due to radiation from side walls; Fig. 3 has several times as much radiating surface. In Fig. 1 the fire is at all times accessible and under control, and can be either banked or drawn in a few minutes; in Fig. 3 there must be maintained not less than three feet of fuel, involving time in starting up and stopping, and heavy standby losses.

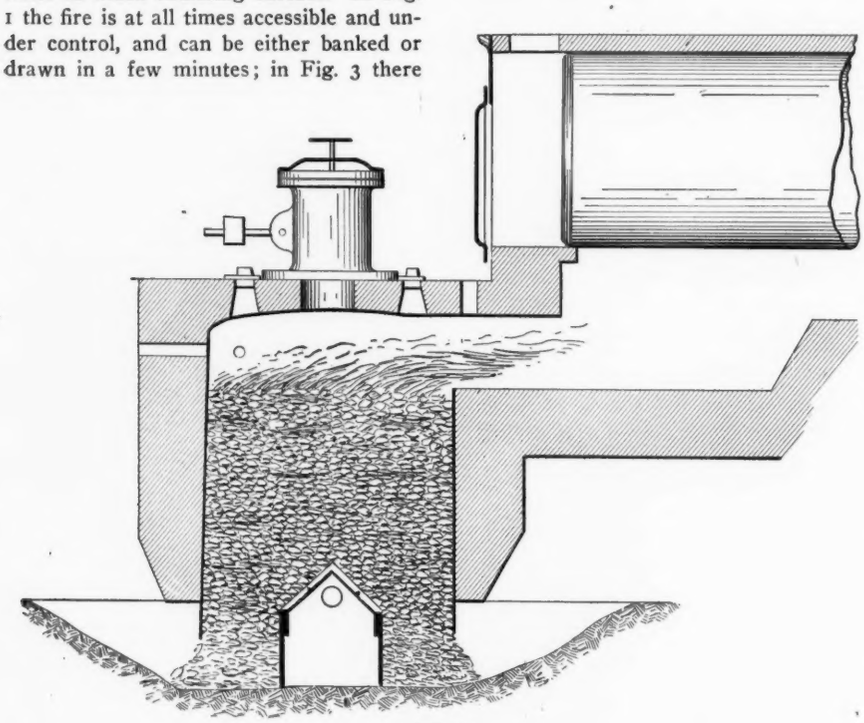

FIG. 3

The furnace shown in Fig. 1 lends itself to a wide range of fuel—it takes what comes; Fig. 3 must be designed and operated to suit the fuel, and certain fuels are not usable with any design. Ash and clinker are readily removed from Fig. 1; when masses of clinker form in Fig. 3 there is "trouble going to waste"; the only way to prevent their forming is by the intelligent use of steam. But no steam can be used when the producer is banked. Consequently, with an easily fusible ash, the clinker will form during that time, demanding a grievous poking and barring-down to get the producer into gas-making condition. How "grievous" it is to get a producer back into gas-making condition when it has once got "out of whack" only those know who have had it to do. Suffice it to say that cleaning a boiler furnace is trifling compared to it. In fact, every mechanical operation involved in cleaning and maintaining the fire is more easily performed with the apparatus in Fig. 1 than with that in Fig. 3.

But, admitting all the foregoing, it will still be contended that for large installations the gas producer has advantages over direct firing in that a battery of gas producers may be installed at a distance from the boiler plant, and in this installation all matters pertaining to coal handling and ash removal can be worked out to a greater economy than if the furnaces were located directly beneath the boilers. In the absence of definite proof we are supposed to take this statement on faith. But overhead coal bins, ash and coal conveyers are just as well adapted for use in connection with a battery of boilers as they are in connection with a battery of gas producers. In each case it is only a question of working out details, and in the case of the boilers the details have all been worked out in many installations. Furthermore the placing of the gas producers at a distance from the boilers necessarily involves heat losses in the transference of the gas. Based upon cold gas it is very doubtful whether better than 80 per cent. efficiency is obtained in good producer practice. Certainly the average producer practice is nearer 60 per cent. than 80 per cent. If a boiler will absorb 75 per cent. of the heat delivered to it, it is doing good work. With an efficiency of 80 per cent. at the producers and 75 per cent. at the boilers, there is resulting efficiency of 60 per cent. for the combination. Such a result has little to commend itself to the man who pays the fuel bills. He had better stick to direct firing.

It is frequently maintained that the changes of temperature to which a boiler is subjected, due to the opening and closing of furnace doors, are productive of excessive strains and are very destructive to the boiler, and consequently, producer-gas firing is conducive to longevity. While changes of temperature are not good for a boiler, yet if they were as destructive as represented boiler makers would be busier than they are. Those who fear the destruction of their boilers from this cause will find an easier remedy in the intsallation of automatic stokers than in the installation of gas producers. Just how many times the furnace doors may be opened and closed before the boiler is injured, the boiler insurance companies have not determined. Neither they nor the owners of boilers need worry about it. But it is a good point for stoker salesmen and gas-producer advocates to talk about.

To a certain extent the gas producer does offer a remedy for the "smoke nuisance." It does it at the expense of increased first cost, labor, fuel and maintenance. An equivalent expenditure to secure the best boiler setting, the highest skill in firing and the best practice attainable will, in the judgment of the writer, accomplish as good results with direct firing of the furnaces.

The gas producer has a field of its own far removed from the boiler furnace. To obtain fuel economy in steam generation we must look, not to the gas producer, but to the setting, grate bars, draft, heating surface, feed-water and boiler design. After all that is attended to we must look to the "man behind the shovel," for he is a very important factor in the equation. And a greater degree of skill, experience and intelligence is demanded of a good gas maker than is demanded of a good boiler fireman.

J. W. Sothern, member of the Institute of Engineers and Shipbuilders, in Scotland, in a paper read before the West of Scotland Polemen, Engineers and Draughtsmen's Association recently, in comparing pressure with impulse and reaction is reported to have said: "In the cylinder itself the steam acts by pressure and expansion on the piston after having overcome the effect of gravity on the moving parts and the friction of the same; this again is repeated at each successive valve and cylinder, so that a considerable amount of energy is expended in turning around and moving up and down tons of material, not to mention the face friction of the valves and pistons, piston-rods, shoes, etc."

When the learned gentleman sees this utterance in cold type, we surmise that he will wonder how much energy can be expended in moving tons of material up and down between the same planes if the friction is not taken into account.

Geological Survey's Experiments to Increase Boiler Efficiencies

Experiments now being conducted by the boiler division of the United States Geological Survey fuel-testing plant at St. Louis, Mo., on the nature of boiler efficiencies, have suggested that stationary boilers ought to be made to do from ten to twenty times as much work per unit of heating surface as at present. This great increase in capacity is to be attained by subdividing the heating surface and water streams more finely, allowing less restriction of the water inside the boilers, and by using high forced and induced draft to put a large mass of gases through the boiler at a very high speed.

Up to now there have been only vague ideas among engineers as to what factors influence the efficiency of the steam-boiler portion of the steam-generator apparatus so as to cause it to absorb more or less of the heat generated by the combustion. John Perry, a distinguished mechanical and electrical engineer of England, went into the subject mathematically a few years ago, and set forth general conclusions tentatively in his book on the "Steam Engine and Gas and Oil Engines."

About a year ago, the Government testing plant took up the mathematical investigation of the theory of the steam boiler and of heat absorption, and extended Mr. Perry's theory somewhat. For some time past Walter T. Ray, assistant engineer, acting under the supervision of Prof. L. P. Breckenridge, engineer-in-charge of the boiler division, has been conducting a series of experiments on small multi-tubular boilers so dimensioned as to enable the theory to be verified, modified, or refuted. The boilers are fed with air heated electrically. Mr. Perry's theory states that, modifying conditions being omitted from consideration, every boiler will always absorb by convection from the gases passing through it the same percentage of heat which could possibly be absorbed by any boiler containing water at a given steam temperature. This efficiency is, therefore, independent of the temperature of the entering gases and of the amount of gases flowing through the boiler. Of course, it must be understood that the above statement of the theory is slightly subject to modification even theoretically, and more so in practice.

As a practical example, assume that the water in a boiler circulates with entire freedom, which is an unwarranted assumption, and that its temperature is 300 degrees Fahrenheit; let the gases enter the boiler at 1300 degrees Fahrenheit, then the difference between the two is 1000 degrees Fahrenheit, and consequently it would be possible for a boiler infinitely long to reduce the temperature of the gases passing through it to 300 degrees Fahrenheit. Further assume, however, that the gases leave the boiler at 500 degrees Fahrenheit, which is 200 degrees above steam temperature. The efficiency of the boiler then is 80 per cent., because it has reduced the temperature 800 degrees out of a possible reduction of 1000 degrees.

If the same boiler be supplied with gases at 2300 degrees Fahrenheit, the gases enter the boiler at 2000 degrees Fahrenheit, above steam temperature. Mr. Perry's theory states that this particular boiler will reduce these gases 80 per cent. as much in temperature as would a boiler infinitely long; that is, to 400 degrees above steam temperature, which is 20 per cent. of 2000 degrees, or to 700 degrees Fahrenheit. It will be noticed that the mass of gases does not enter into consideration at all.

This surprising deduction is being accurately verified by the boiler division of the Geological Survey, from which it is found, when keeping other conditions the same and the initial temperature of the gases constant, that the final temperature of the air remains the same, whatever the amount of air sent through the boiler per second. So far the upper limit has not been reached with tubes clean inside and out, although the rate of evaporation has already been pushed up to many times that obtained even in locomotive practice.

Mr. Perry's theory takes into consideration four fundamental features affecting heat absorption at any point of the heating surface:

First, temperature difference between the gases outside any portion of the boiler tube and the water inside.

Second, the number of molecules per cubic inch in the gases outside the boiler tube.

Third, the specific heat of the gases at constant pressure.

Fourth, the velocity of the gases parallel to the heating surface.

Of the four above factors, only the first has usually been considered. It will be readily seen that if the temperature of the gases is increased the number of molecules beating against any square inch of tube-heating surface is decreased, and thus the second factor largely neutralizes the first, especially at high furnace temperatures. The third factor can be taken as constant equal to 0.24.

The fourth factor is the new and surprising one. Mr. Perry considers that a high velocity of gases parallel to the heating surface scrubs off more or less of the dense film of gases adhering to the metal surface, which film of gases has already become cold by proximity to the metal. The higher the velocity of gases the more the scrubbing effect, and consequently the greater the amount of heat transmitted. This theory necessarily assumes that the ability of the metal to transmit heat is practically infinite, and when it is considered that ordinarily there is never put through a boiler tube more than 1/1000 of heat it could possibly carry, it will be realized that this assumption is warranted.

It is anticipated that Mr. Perry's theory and the survey's verification of it will result in placing the steam boiler on a fairly secure mathematical basis, as is the case with generators and motors at present. Thus far the experiments check out the theory excellently. The theory and results will be embodied in a special bulletin to be published in two or three months, to be followed by later bulletins as the work proceeds.

Obstacles to Progress in the Producer-gas Industry

By H. Cole Estep

The two chief difficulties confronting the producer-gas industry in the United States are found in the dearth of men competent to operate the plants already installed and in the unwillingness of certain manufacturers of producer-gas machinery to take any interest in the career of their plants after they have been erected and paid for. The recent partial failure of one and the complete failure of two of the three producer-gas plants in one of the largest cities of the northwest, resulting in the almost total paralysis of the gas-producer business of that city, is a concrete and pertinent example of the effect that these two difficulties have on the development of the producer-gas power industry.

The difficulty as to poor operators is of two kinds: first, the owners of the plants have trouble in getting men who know enough to operate a producer intelligently; second, the gas-producer manufacturers are unable to get the right sort of men to send out with their new plants to instruct the owners or their employees how to run a producer successfully. The improvement of the efficiency of the first class of men hinges on obtaining better results from the second class, for it is they that teach, or are supposed to teach, the others their business. The trouble is not so much that the men sent out by the manufacturers do not know their business, or are unable to instruct the men under them, but that they pursue, with singular unanimity, a policy of telling no more about how to operate a producer than they are absolutely obliged to tell.

The writer has been informed upon reliable authority that although there is no formal organization among the men who are employed to erect producer-gas plants and instruct the owners in their operation, yet there seems to be a "gentlemen's agreement" among them to impart no more information than that which they

cannot help giving out. An illustration will serve to emphasize this. A producer plant situated in the north central part of this country failed to operate. The manufacturer sent a man up to investigate the trouble and he found that the operator was trying to operate the suction producer with the air blast which was used in starting going full tilt. The excess pressure in the system forced the gas out through the air intake of the engine. The manufacturer's man shut down the blower and a few minutes later started the engine, but offered no explanation of the difficulty to the operator and it is doubtful if he knows yet just what was wrong. Similar tactics are largely responsible for the failure of the plants mentioned in the first paragraph of this article. The reason for this policy seems to be that through its practice the men are able to pose as expert trouble-men and to assume a dignity that they do not deserve. The policy is one, however, that is working considerable harm to the producer-gas industry, as the instances cited show.

One of the plants just referred to, although a total failure and the source of considerable loss of prestige to the manufacturer, as well as to gas-power interests in general, has never been visited by any of the manufacturer's agents since its erection nor has the builder of the plant ever manifested any interest in its success or failure. It is fortunate for the gas-producer industry that this type of manufacturer is in the minority, for he is, just at present, working about as hard (blindly, of course,) to pull down the business as the broader-minded firms are in building it up. This same sort of business policy is responsible for such expressions as this, which came from the operator of a recently installed plant: "To get the money seems to be the principle of the manufacturers."

That such a policy does not contain the elements of substantial success is clearly shown by the history of a certain small firm of gas-engine builders on the Pacific coast which has always done business on just the opposite principle. This firm makes it a point not only to build the best machinery it can but it gives with every plant an unconditional guarantee, without a time limit, to replace or repair without charge any part showing faulty material or workmanship for which it is responsible. Further than this, the firm takes a personal interest in every installation, is careful to see that every plant is properly erected, and that the owner or operator is fully instructed in its manipulation. It carefully investigates any troubles that arise in the operation of the plant and points out to the owner just wherein his mistakes have been made. The firm is making money, and although it spends little or nothing on advertising, the excellence of its work speaks so loudly for itself that the factory is continually congested with orders.

In this article the writer has, in justice to the manufacturers concerned, mentioned no names or places but the cases cited are all authentic.

[Fortunately, as our contributor points out, the ostrich type of manufacturer is in the minority. We know of some builders of power-gas apparatus who send an experienced man out on each installation and keep him with the plant until the resident engineer becomes thoroughly competent to handle it intelligently. These factories are also "congested with orders." —Editors.]

Voltage Lost in Direct-current Wiring

By N. A. Carle

The determination of the drop in voltage in direct-current wiring is based upon Ohm's law.

Formula:

$$I = \frac{E}{R}, \qquad (1)$$

where

I = Current in amperes,
E = Loss in volts,

and

R = Resistance in ohms.

The resistance is that of the entire circuit and varies with the length of circuit, area of cross-section and the specific resistance of the material of the wire. Copper wire only is considered in this case and the basis of specific resistance is that of a piece of copper wire 1 foot in length and 0.001 inch in diameter. This is called a mil-foot, and its resistance varies with the purity of the copper and its temperature. A resistance of 10.7 ohms per mil-foot is taken as representing average conditions.

Formula:

$$R = \frac{r \times L}{c.m.}, \qquad (2)$$

where

R = Total resistance in ohms,
r = Specific resistance of copper wire,
L = Entire length of circuit, in feet,

and

$c.m.$ = Area of cross-section of wire in circular mils = diameter^2.

Combining equations (1) and (2) and substituting the resistance of one mil-foot the formula becomes

$$\frac{I \times L \times 10.7}{c.m.} = E.$$

This is usually expressed as:

$$\text{Volts lost} = \frac{10.7 \times \text{amperes} \times \text{length of circuit}}{\text{circular mils}}.$$

The charts on pages 517, 518 and 519 are designed to read directly the volts lost for different strengths of current transmitted over various sizes of wire of different lengths. The carrying capacities for different sizes of wire as specified by the fire underwriters are indicated on these charts by the curved lines cutting across the radial lines representing the wire sizes.

Chart No. 1 covers currents up to 60 amperes for wires from No. 14 to No. 5, B. & S. gage, with lengths of circuits from 25 to 350 feet and for drops up to 7½ volts.

Chart No. 2 covers currents up to 150 amperes for wires from No. 1 to No. 9, B. & S. gage, with circuit lengths of from 50 to 350 feet and for drops up to 7½ volts.

Chart No. 3 covers currents up to 300 amperes for wires from No. 4 to No. 0000, B. & S. gage, with lengths of circuits from 200 to 1400 feet, and for drops up to 15 volts.

Example

How many volts would be lost in transmitting 48 amperes on open wiring from a feeder line to a point 100 feet distant, using the smallest size of wire allowed by the Fire Underwriters?

The whole length of circuit would be 200 feet. Using chart No. 1, start with 48 "amperes" and read up to No. 7 "Size of Wire," which is within the fire underwriters' limit for "Open Work," then across to 200 feet "Whole Length of Circuit," and down to 4.9 "Volts Lost." It is to be noted that if this had been concealed wiring, a No. 5 wire would have been required, according to the underwriters' limitation, giving a drop of 3.1 volts.

Example

What would be the proper size of wire and amount of current carried for a 10-volt loss on a circuit of 600 feet total length, and how many amperes could be carried, using weather-proof insulation in open work?

Using chart No. 3, start with 10 "Volts Lost," read up to 600 feet "Whole Length of Circuit," then over to No. 000 "Size of Wire," which comes within the limit of the underwriters' requirements, and down to 260 amperes. Following up this No. 000 line to its intersection with the underwriter's limit line, and then down, it will be found that the carrying capacity is 262 amperes. For this capacity the drop will be found to be 10.1 volts.

It is to be noted that with rubber insulation and concealed work a No. 4 wire would be as large as could be used for the same drop, and it would have a maximum carrying capacity of only 65 amperes.

A triple leather belt will transmit 13 horse-power per inch of width at a speed of 5000 feet per minute. At lower speeds the power transmissible is proportionately reduced.

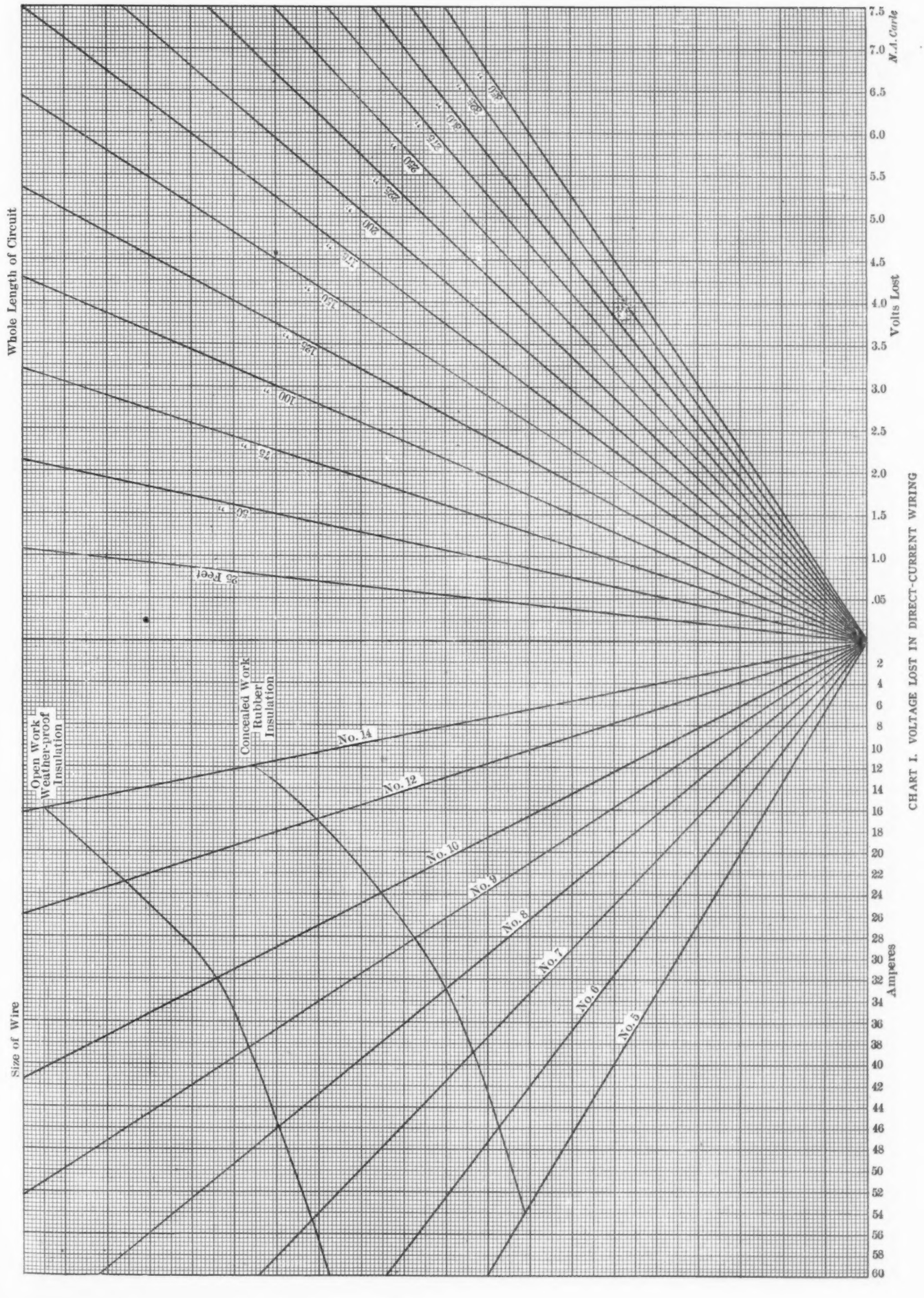

CHART I. VOLTAGE LOST IN DIRECT-CURRENT WIRING

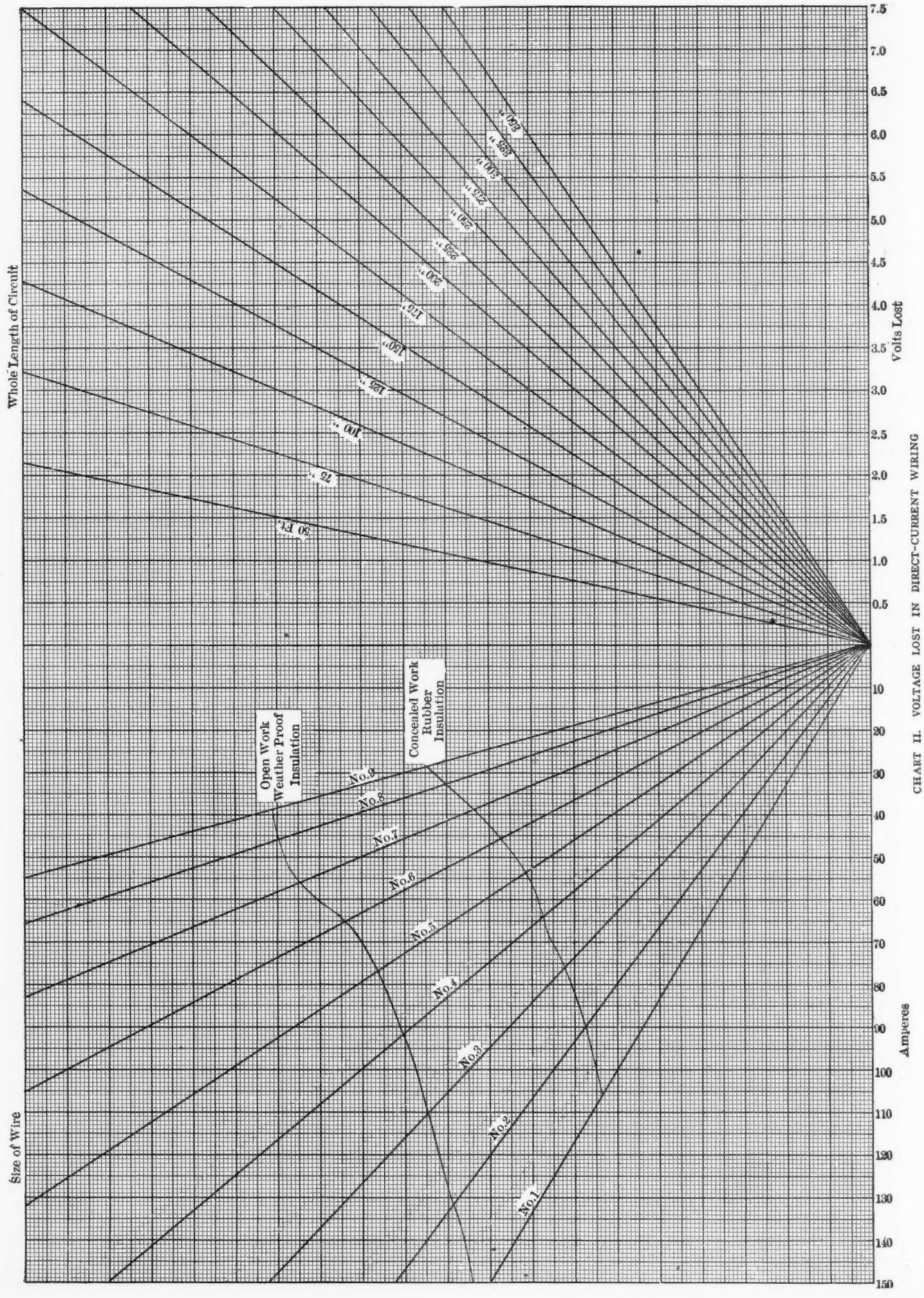

CHART II. VOLTAGE LOST IN DIRECT-CURRENT WIRING

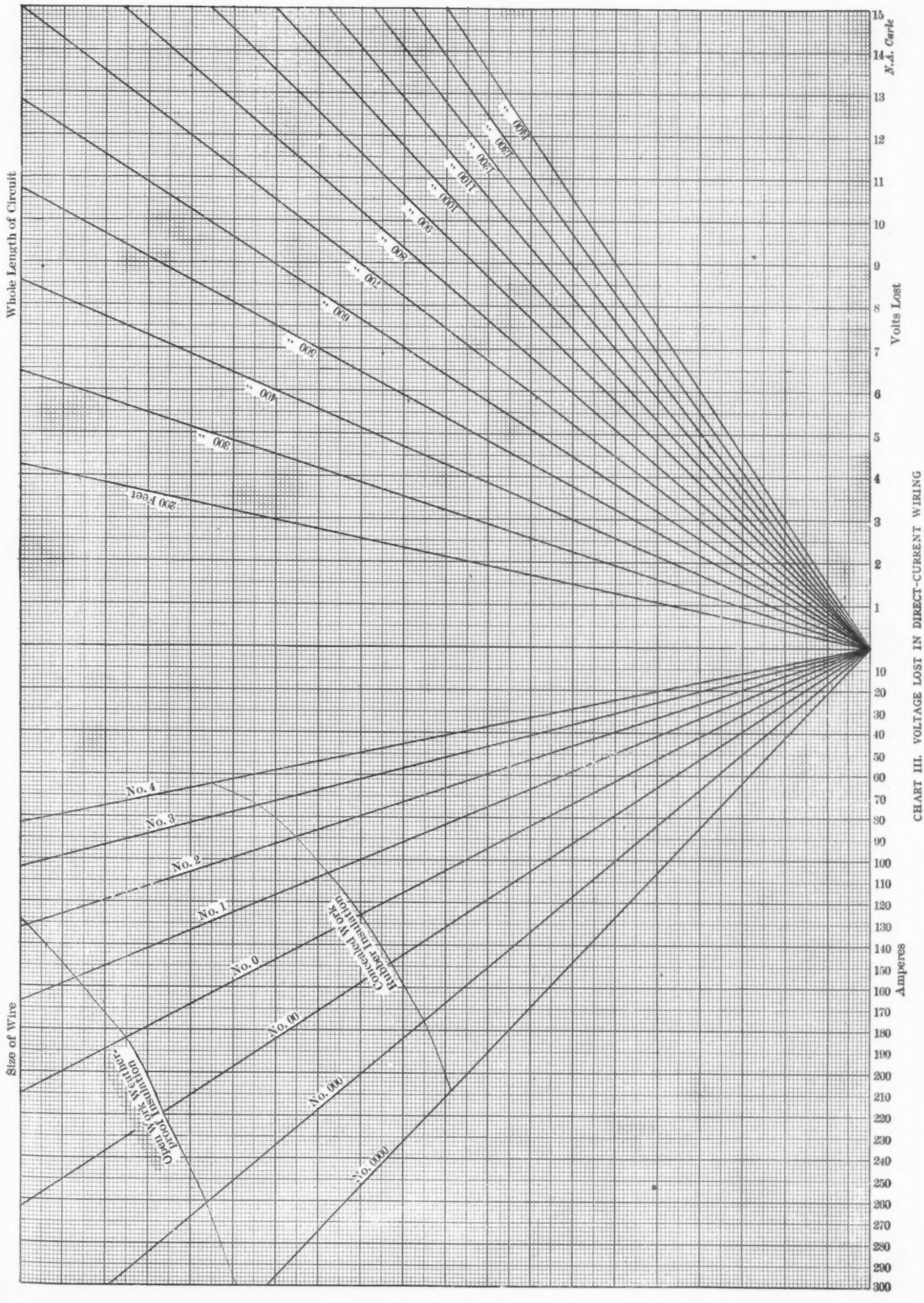

CHART III. VOLTAGE LOST IN DIRECT-CURRENT WIRING

The Operation and Care of Injectors

A Practical Discussion of the Leading Types, Explaining Their Action and the Most Approved Methods of Connecting

BY W. H. WAKEMAN

Injectors are now regarded as more reliable as boiler feeders than ever before in their history, but there are numerous points to be learned and remembered concerning their operation and care, neglect of which will surely result in their failure when they are most needed, and such failure will probably cause an annoying and expensive shut-down. This applies alike to large and small plants.

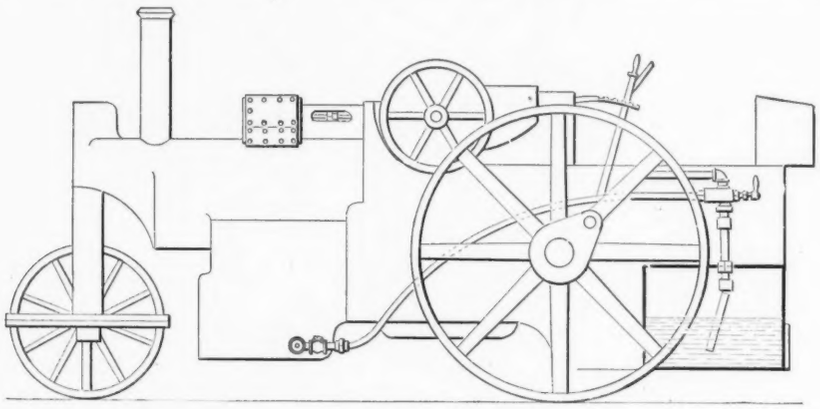

FIG. 1

Fig. 1 shows an ordinary road roller fitted with a water tank located under the engineer's position as he stands to fire his boiler. Such a tank must have a tight cover in order to exclude pieces of coal and other extraneous matter that are not wanted in an injector. This of course

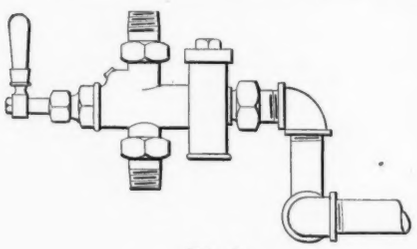

FIG. 2

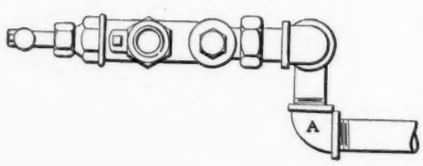

FIG. 3

makes it impossible for the engineer to see the suction pipe of his injector, therefore he cannot easily tell whether it is in good condition. As a rule, such a pipe will not become deranged after it is once put in good order, but in this case it was necessary to repair the tank, and the suction pipe had to be removed for this purpose. Such a tank is small and not very convenient to work in, hence when the pipe was replaced, it was not screwed into the coupling properly, but was caught at an angle and not made tight. It did not always leak enough to prevent it from taking up water and discharging back into the tank, but it would not feed the boiler steadily. It would always be better if such pipes could be exposed to view, but with this class of machinery space is valuable, and the parts must be made as small as possible and located closely together in order to bring the whole within narrow limits, because the entire outfit must be in shape to be readily transported from place to place.

Fig. 2 illustrates an ordinary injector without connections, except a small part of the discharge pipe. This is presented as I found it, with three ells located in a distance of less than one foot. Fig. 3 is a plan view of the same injector. Let us see what the objections are to this arrangement of fittings. When water is discharged by an injector into the pipe which conveys it to the boiler, it travels rapidly, hence when it strikes a short turn at right angles, as it does when an ordinary ell is used, much of the momentum is taken up by changing the direction in which the body of water is moving. In this case one change is made, in turning the water from a horizontal to a vertical direction (see Fig. 2), and as soon as this change is made it strikes another ell which turns it back to a horizontal motion, after which it passes through another ell, *A*, Fig. 3, that turns it sharply to the right.

In this connection it must be remembered that an ordinary injector is only intended to deliver water against a few pounds more than the steam pressure which drives it, therefore this combination of three ells close together helps to make resistance to the movement of the feed-water, and thus reduces the working difference between the two pressures.

It is so very seldom necessary to use so many ells close together, but if it is required in some special case they should be one size larger than the feed-pipe demands, thus reducing friction by allowing more room for the turns. In the case under consideration they were made one size smaller than the injector fittings which, of course, increased the friction. This particular case is mentioned in detail because it gives the reader a better idea of the objectionable features, than to lay down general rules and directions to be followed. If fittings for such service were made longer and given easy curves instead of such sharp turns, the result would be more satisfactory. To overcome this objection the plan of bending the pipes is adopted, but this cannot be done

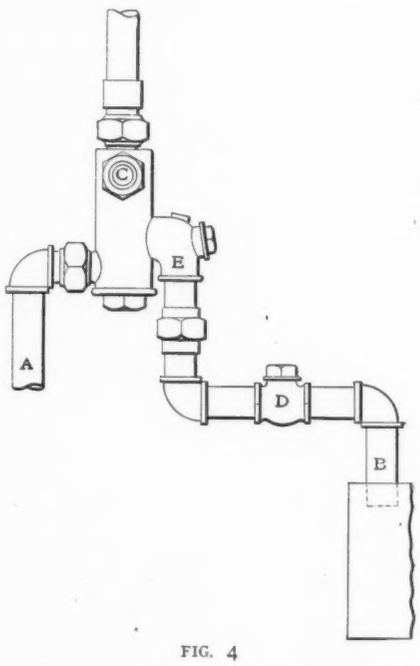

FIG. 4

in all cases, and unless care is taken to do the job well the pipe will be flattened, which will reduce its capacity more than the sharp turns caused by ordinary ells. If the pipe to be bent is filled with sand and a coupling with a plug in it put on

each end, it will assist in keeping the pipe round.

Automatic Re-starting Injectors

A few weeks ago I had some trouble with an automatic re-starting injector that proved interesting. This injector is illustrated in Fig. 4, in which *A* is the suction pipe, *B* the overflow to a tank,

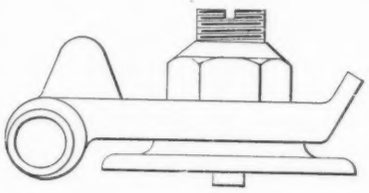

FIG. 5

and *C* the discharge to the boilers. There is a check valve *D* in the overflow that was not there originally. This injector became gradually more and more unreliable until it would not work at all; but fortunately there are two other injectors and two pumps that can be used. When steam is turned on to this injector, it draws water through *A* and allows it to overflow until a valve in the feed-pipe is opened, when water goes into the boilers. The overflow valve *E* is nothing more than a check-valve opening outward for the discharge of water, but when the injector is feeding the boilers this valve closes to prevent air from entering. About twelve years of service caused this valve to leak, but owing to the fact that it draws in air instead of allowing water to drip into the tank, it did not attract attention to the cause of failure.

The cap of this overflow valve *E* was removed, showing that the hinged disk, Fig. 5, was made to receive a screw-driver for the purpose of turning it when it needed to be "ground in," as it certainly did at the time referred to. A little fine emery, or some of the dust found in the trough under the grindstone, if put between the surfaces, will grind off the high spots and tend to make a tight joint. This point I have already mentioned, but when using the screw-driver it is better to turn it, say, one-quarter of a revolution in one direction, and then turn it back again, rather than to always move it in one direction, as when turning a screw into place. The philosophy of this is that if a small piece of the emery, or whatever is used to grind with, sticks to the revolving disk, it will cut a tiny groove that can scarcely be seen by the casual observer, and which does not stop the leak; but if the motion is reversed frequently, better results are usually secured. In this case it was difficult to secure an absolutely air-tight joint, even with good facilities for doing the work, therefore I put another check-valve in the pipe as shown at *D*. It is fitted with a hard-rubber disk which was not tight when first tried, and I did not expect it to be, because these disks are comparatively rough when new, whether the entire valve is new, or only a worn-out disk has been replaced by a better one. These valves, and all other kinds having a hard-rubber disk, are intended for use on steam pipes, or very hot water pipes, consequently the heat softens the disk and makes it fit the seat. In this case hot water was run through the overflow pipe for this purpose, until the disk was well heated.

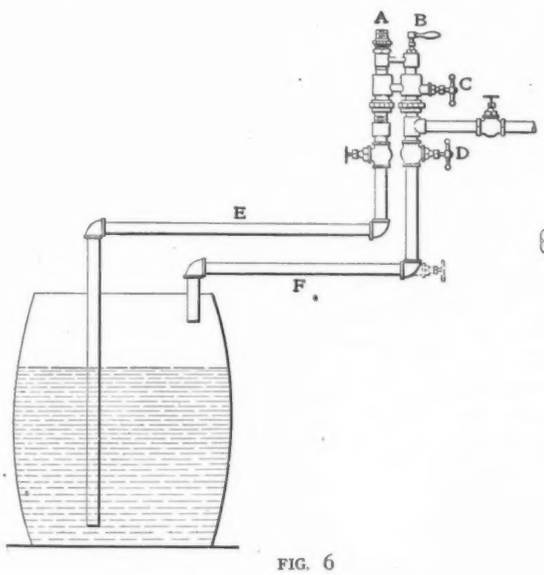

FIG. 6

There is another way in which a leak in the overflow may be prevented from causing trouble, and that is by carrying the end of the pipe below the water line in the tank. In this case water is drawn in through the leak and goes to the boiler, doing no harm. When the injector is started the overflow pipe is heated by escaping water, and if this pipe gradually assumes the temperature of the room in which it is located, it shows that no leak exists in it; but if it becomes colder at once, it indicates the passage of water, as already mentioned.

The Inspirator

Fig. 6 illustrates a very different kind of an injector, known as an inspirator. The question concerning the difference between an injector and an inspirator is frequently asked by steam users and engineers, and in reply I would say that there is no difference, as the inspirator is one kind of an injector. All injectors may be divided into two classes, namely, the single- and the double-tube kinds. Fig. 4 illustrates the former, as there is but one set of tubes in it, which must do both the lifting and the forcing. Fig. 6 illustrates the latter, as it contains two sets of tubes. When steam is admitted at *A* the valve *B* is closed, but *C* and *D* are open; therefore water is drawn up through the suction pipe *E* and is returned through *F* to the barrel or tank. When this has circulated long enough to insure dry steam coming to the inspirator, close *C*, the effect of which is decrease the lifting power, and open *B*, thus admitting more steam to the forcing side and raising the temperature of the escaping water. Do not let this continue too long, or it may heat the water in the barrel until the inspirator will not take it; for it should be remembered that the incoming water must be cool enough to condense the steam, or else the machine will not deliver water against boiler pressure. Slowly close *D* and the water will go into the boilers, provided that all valves in the feed-pipe line are open. I have seen many failures to start an inspirator simply because the valve *D* was closed with a jerk that brought a heavy back pressure to bear for an instant, but that was long enough to "break the jet" of water, making it necessary to start it over again.

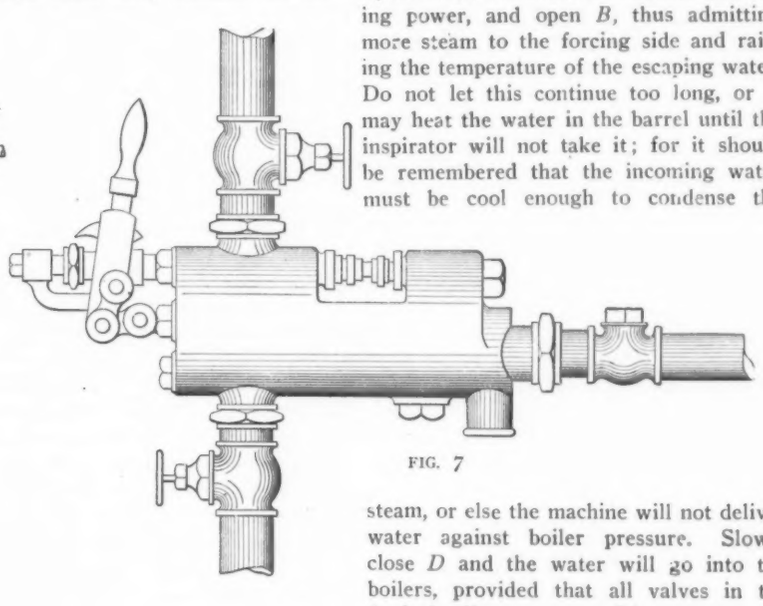

FIG. 7

After an inspirator has been used for a long time, the valve *D* may leak, thus allowing more or less of the water to flow back into the barrel. It is quite possible for the capacity of the machine to be much reduced in this way, which also causes a loss of heat that is not good practice. The valve *D* should be "ground in" and made tight, or another valve with a hard-rubber disk may be added, as shown by the dotted lines. Of course it will be understood that this is not a defect that is peculiar to an inspirator, as any other form of injector may become worn in the same way and require similar repairs.

I have another kind of double-tube in-

jector that gives very good results in practice. It is illustrated in Fig. 7. Neither barrel nor tank is used in this case, as water under pressure is supplied directly to the injector. The practical difference between these two injectors, both of which are fitted with double tubes, is that when handling Fig. 6 it is necessary to adjust each valve separately; but with Fig. 7 they are connected to one lever, hence when this is moved, it takes them all together, which is a very convenient arrangement, provided it is in perfect order; for in this case all valves much reach their limit of movement at the same time or else the machine will not deliver water to the boilers. If the movement is not equal, there is no convenient way for compelling such action.

Action of the Injector

Having presented many practical points concerning the operation, care and repairing of injectors, it is in order to explain the action of this useful device, as every man who uses an injector should understand the theory of its action; for in this, as well as in other branches of steam

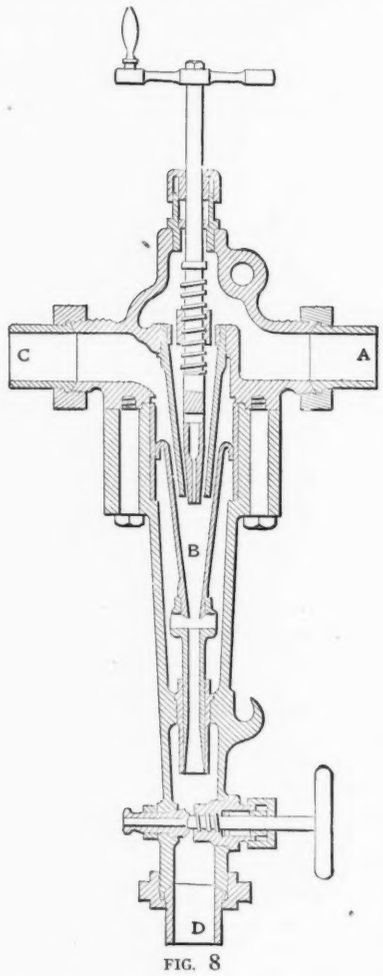

FIG. 8

engineering, practice and theory are closely allied, and the man who attempts to rely on one and ignore the other, although he may attain a certain degree of success, will come short of that full measure of perfection that belongs to every man who fully masters the details of any complicated process pertaining to modern machinery.

In California there are several noted water powers in which the head is several hundred feet, giving a very high pressure to the water where it is used on water-wheels. If there is a slight leak in the pipe which conveys it down into the val-

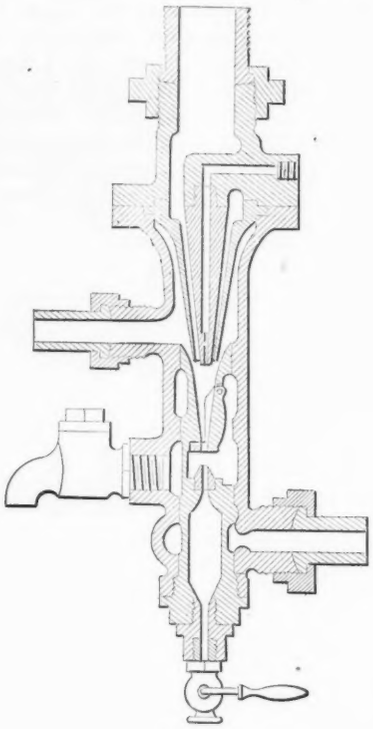

FIG. 9

ley, water comes out in a thin but very powerful stream, or jet, and where such a leak is discovered it is very natural for an inexperienced person to let the water play upon his hand, but one such experience is usually enough, as the great force due to such a high pressure is sufficient to peel the skin and flesh from the hand as if it were done by a steel knife. This action is of course due to the momentum of the body of water, caused by pressure behind it, but after it has escaped from the pipe, pressure can no longer control it, and its action is due wholly to momentum. Is it not easy to imagine such a jet of water as going into another pipe under pressure in direct opposition to that pressure?

When steam at 120 pounds pressure enters an injector under perfect conditions, its velocity when expanded is more than 1400 feet per second. If it enters a vacuum of 22 inches under similar conditions, this great velocity is increased to 3400 feet per second. While moving at this high speed it strikes a body of motionless water and is at once condensed, after a portion of the momentum has been imparted to the water in the process. The natural consequence is that a comparatively heavy body of water is given momentum enough to make it enter the boiler against full pressure.

Fig. 8 illustrates the Giffard injector in one of its earlier forms. Steam enters at *A* and is discharged through the contracted nozzzle shown into the chamber *B*. Water enters at *C*, and coming into contact with the steam in the chamber *B* is given momentum as above described. Passing down through *D* it enters the feed-pipe and is thence delivered to the boiler. I have been told several times that if a tallow candle is put into the barrel of a gun, with a charge of powder behind it, the candle can be driven through a pine board when the gun is discharged. I have never tried this experiment, but it seems reasonable, and if it can be done it is due to the great velocity of the candle when it strikes the board, and the momentum so gained is what causes it to pierce the harder sub-

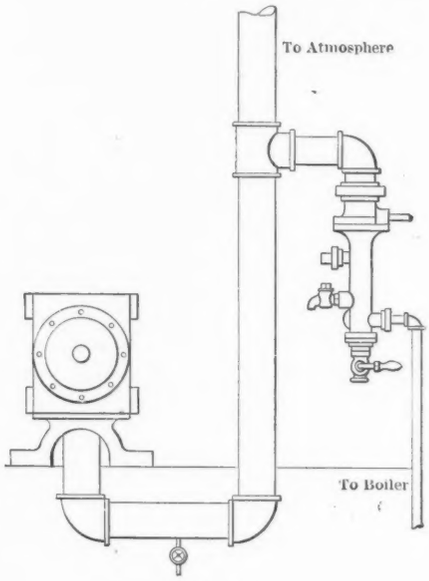

FIG. 10

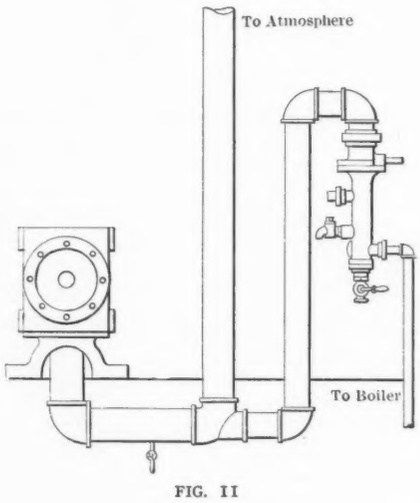

FIG. 11

stance; therefore it ought not to be difficult to understand how an injector can project a column of water against boiler pressure.

In order to show that the pressure of steam has little bearing on the subject,

I call attention to Fig. 9, which is an exhaust-steam injector. It is not necessary to put a back-pressure valve on the exhaust pipe in order to create pressure to run an injector of this kind, as steam is taken at atmospheric pressure and nothing more is needed unless the boiler pressure exceeds 75 pounds, and even then only a small jet of live steam is required. This is sufficient to feed the boiler when the engine is shut down, which is very convenient where the work to be done does not require power every hour in the day.

The condensation of a comparatively large volume of steam creates a vacuum into which the water to be fed rushes with great speed and thus the required momentum is secured.

While the exhaust-steam injector does not require pressure for its operation, it does need a good supply of steam, hence the piping must be correctly arranged, or it will not work well. Fig. 10 illustrates a defective plan for this work, as it shows a vertical exhaust pipe fitted with an ordinary tee. Of course some of the steam will go to the injector even with this arrangement, but it will not get enough to secure positive operation, and I have seen one that would not work at all; but when the piping was changed to the plan shown in Fig. 11, it worked perfectly. It is not hard to see why this worked better than before, as all of the steam that can get into the injector pipe will go there, and what cannot find its way here must turn and go out of the free exhaust outlet. As the steam fitter in this case could not collect pay for the work done in piping it up as shown in Fig. 10, he had to change it to Fig. 11 at his own expense. This should be a warning to both steam users and steam fitters, because such blunders always prove expensive to both.

A Practical Filing System for Clippings

By Lloyd Yost

Several years ago the writer not only discovered that his collection of periodicals was becoming cumbersome, but that the proportion of reading matter which was of real value to him was far exceeded by that for which he had no use. Someone suggested removing the advertisements from the publications, thus largely cutting down the bulk, but a great many of these advertisements were of worth, so that wouldn't do. From a magazine like Power, for instance, a progressive engineer or mechanic can glean a large amount of useful information from the "ads" alone in the course of a year. After a while the plan was adopted of clipping and filing articles, using a card index, but it was found that this index was a time-consumer of the first rank, not at all suited to the use of a busy man, who had no clerical assistant to do the work of indexing. In addition, it was necessary to look twice for any article wanted—first in the index, then in the file—and even then articles on precisely the same subject were never together. Consequently, this plan was discarded.

The nucleus of the system finally adopted was found in the one used by William T. Magruder, professor of mechanical engineering at the Ohio State University. Professor Magruder's system was of necessity quite elaborate, as was suited to his work. It was described in the *Proceedings* of the Society for the Promotion of Engineering Education several years ago.

For the system adopted by the writer the necessary equipment consists, first, of one or more ordinary box letter files, covered with marbled paper, which can be bought for 25 cents apiece. They are about 12 inches high, 12 inches wide and 3 inches thick. Those having heavy-paper alphabetical dividing sheets carried by two pins at the back, instead of only one, are much the better. In addition, one needs a common blue pencil, a 15-inch ruler, with metal edge for tearing paper, and a jar of good library paste or mucilage.

When an article has been read and the reader decides it should be filed, he at once draws a heavy blue-pencil ring in the title around the word or group of words under which the article should be filed. This ring should be large enough to be clearly visible. For example, if it is an article on the "Horse-power of Belting," the ring should be drawn around "Belting." If the word under which it is desired to file that particular article does not occur in the title, it should be written in with the blue pencil in legible letters. If no margin is near, thus affording no white space on which to write it should be done directly on top of the printed matter.

After having thus marked each article and advertisement which it is desired to file, begin at the first and tear out the articles by means of the metal-edged ruler. This is a vastly quicker operation than by using scissors and, besides, makes straighter edges. If the article occupies the full column in a periodical having 9x12-inch pages, or larger, cut off the bottom margin, or, if necessary, the top and bottom margins, in order that the sheets may lie flat in the files without folding. The sheets should not be folded unless absolutely necessary, as a folded sheet occupies just double the thickness, and thus halves the capacity of the file. The name of the periodical and the date should always be left intact at the top of the sheet, these being very valuable for reference purposes. If the name and date have been necessarily cut away, they should be written in with the blue pencil. If an article covers more than one sheet, the various sheets should be pasted together at the left margins, always with the "title" on the outside, and always flat. Wire clips should not be used, as they are not permanent, are always catching papers which do not belong to them, and increase the bulk of the files unnecessarily.

The articles are filed by title, alphabetically, according to the guide-sheets in the file boxes. Suppose one wishes to find all his data on belts. It will *all* be found under "B," without consulting any card index. If one removes an article from the file, it is plainly labeled, so that he or anyone else can easily replace it exactly where it was before.

As soon as the index outgrows one file box, another should be added, using the first, say, to file articles from "A" to "K," and the second for "L" to "Z," and the boxes should be so marked on white slips pasted on the backs. The paper guides inside the box should never be removed or destroyed, even though they are not used, as they may be used in the next re-arrangement. With three boxes each would be used for about one-third of the alphabet, and so on.

Sometimes two desirable articles on widely different subjects are on opposite sides of the same sheet. This situation is easily cared for as follows: One is marked for filing in the customary manner. Suppose it is an article on the "Care of Belts," and the article on the back is on "A New Chain Drive." Upon a blank sheet of paper, letter size, write with the blue pencil in large letters, "'A New Chain Drive,' with 'Care of Belts,' Power, Aug. '05." The usual ring is then drawn around the word "Chain," and the letter containing the title is filed under "C." In the same manner one can cross-index, or cross-file articles that he thinks he may afterward look for under a different heading from the original.

Nearly everyone will have one or two special lines of study or work concerning which he will wish to file as many clippings, perhaps, as of all other subjects together. In such a case, it is well to set aside one or more file boxes for material along the special line or lines, and to file such material *only* in this box.

It might be advanced that the sub-divisions of the ordinary letter file are not close enough and that one will be obliged to look through a large amount of matter under one letter or division to find what he is looking for. In practice with the system, this objection does not seem to have much weight, for the reason that the titles of the various clippings are so easily read, since they are in large letters, or made prominent with blue rings, and very little effort is required to note whether they are the articles desired. The writer has used this system for several years and believes it involves the maximum of convenience with the minimum of labor.

A Useful Diagram of Steam Properties

From Which May Be Found the Physical Properties of Moist and Superheated Steam at Different Pressures and Temperatures

BY H. F. SCHMIDT AND W. C. WAY

Though entropy diagrams have been widely used and have had much attention paid them by the European technical press, whereby their simplicity and usefulness have become familiar to the European layman, in America they have been sadly neglected, except by college professors and some few engineers. To the ordinary engineer and most college graduates, the word "entropy" has had some awe-inspiring and mysterious meaning, with the result that any literature in which it appeared more than once has been carefully neglected. It is to try and dispel this mysterious bugbear that the writers have prepared the accompanying diagram of steam properties, hoping that its publication with a few of the almost infinite number of practical problems which can be solved by it without the use of mathematics will be a stimulus to engineers to study it and become familiar with the greatest work and brain saver known to the steam-engineering profession. Its value will also be appreciated by those thousands who are interested in and are working on that question of the hour, the turbine problem.

Without going into the mathematical deduction of the entropy function, for the present purpose no better definition can be given of entropy than to say that the name was derived from the two Greek words *en* and *trope*, meaning a "turning into" or transformation, referring to the *heat per degree* which is transferred to another body or transformed to another form. This is made clearer by writing it thus,

$$\text{Entropy} = \phi = \frac{\text{Heat transferred or transformed}}{\text{Abs. temperature at which transfer or transformation occurs.}}$$

It follows from this definition that the product of entropy and the absolute temperature must equal the heat which is transformed, and since the product of any two quantities represents an area, it follows that the difference between the areas of two entropy-temperature diagrams, one representing the initial and the other the final conditions of the fluid, must represent the heat energy which has been converted into work.

Entropy, from the above definition, has no dimensions, that is, it is simply a ratio, and cannot be said to be a property of a substance in any sense other than it might be said that π is a property of the circle in the expression $A = \pi R^2$. Further, it will be evident that since the total heat of any substance above the absolute zero of temperature is not known, the total entropy cannot be found. Fortunately, this does not affect ordinary calculations, since in general only differences of entropy enter into the calculations, so that the entropy between the absolute zero and the freezing point, from which entropy is usually calculated, disappears by subtraction. Consequently, in the published entropy tables of steam, the entropy is calculated from 32 degrees Fahrenheit, as is also the total heat in the water and steam.

The entropy of steam will evidently be composed of two components, first, that of the water while heat is applied to it as such and the temperature is constantly changing, and secondly, that of the vapor, since during the vaporization the temperature remains constant while the heat is being added. Therefore the entropy of steam will be written

$$\phi = \phi_w + x\phi_s,$$

ϕ_w being the entropy of the water and ϕ that of the vapor, while x is that portion of the original pound of the liquid which has been vaporized.

The method of constructing the diagram was as follows. The entropy of water above 32 degrees Fahrenheit (not shown on the diagram as published) was plotted from Peabody's tables, and then the entropy of the vapor plus the water, which may be called the saturation curve, since all points on this curve (marked on the diagram $x = 1$) represent the condition of dry saturated steam, was also plotted from Peabody's tables by adding the entropy of the vapor to that of the liquid.

The construction of these two curves is indicated in Fig. 1, the line *B-A-C-D-E* being the entropy of the liquid and *F-J-K-L* the entropy of the vapor plus the liquid; hence, *E-F* will be the entropy of one pound of steam. Since *E-F* is the entropy of one pound of steam, or at some other pressure and temperature *D-J* or *C-K* is the entropy of one pound of vapor, if only 0.90 of a pound, say, has been vaporized, then the entropy of the vapor would be only 0.90 of *E-F*, *D-J* or *C-K*, etc., and the points *T*, *S*, *P*, *M*, result; similarly, the points *U*, *R*, *Q*, *N* are obtained when only 0.80 of a pound has been vaporized, and so on. The curves $x = 0.99$, $x = 0.98$, etc., on the large diagram were laid off by dividing *E-F*, *D-J*, etc., into 100 equal parts and drawing curves through the points thus located.

As the temperature of saturated steam at any given pressure is constant, regardless of the amount of moisture which it contains, the lines of constant pressure in the wet-steam portion of the diagram will coincide with the temperature lines corresponding to the different pressures. The pressure lines are, therefore, simply straight lines parallel to the bottom of the diagram, meeting the constant-pressure curves of the superheat portion of the diagram at the saturated-steam curve.

The dotted lines of constant specific volume were calculated by the formula $v = v_1 x + v_2 (1 - x)$, where v_1 equals the specific volume of one pound of dry saturated vapor, and v_2 equals the volume of one pound of the liquid at the corresponding temperature and x equals the quality of the steam, that is, the portion of one pound which is vapor. For the larger volumes the quantity $v_2 (1 - x)$ becomes so small that it was neglected. In the superheated area, to the right hand above the saturation curve, the specific volumes were calculated from Schmidt's formula based on Hirn's experiments and published in POWER:

$$v = 0.593 \frac{441.1 + t}{p},$$

in which p is the absolute pressure in pounds per square inch, and t is the temperature of the superheated steam in degrees Fahrenheit. As this formula does not give accurate results for only a few degrees of superheat, and therefore all the curves in the superheated and saturated areas do not meet at the saturation curve, some of the curves of constant volume were stopped before reaching the saturation curve.

In the superheated portion of the diagram the lines of constant pressure were calculated from the formula

$$\phi_s = c \log_e \frac{T'}{T_s},$$

in which c equals specific heat of superheated steam, taken at 0.48; T' equals the absolute temperature of the superheated steam, T_s equals the temperature of saturated steam of the given pressure, and ϕ_s is the entropy of the superheated steam above that of saturation at the same pressure. ϕ_s was, of course, added to the entropy of the saturated vapor, which gave the entropy of the superheated vapor above 32 degrees, and this, with the temperature T', gave points on the curves.